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ORIGINAL ARTICLES.

I.—Notes on the Pycnodont Fishes.

By Arthur Smith Woodward, LL.D., F.R.S.

(PLATE XXIV.)

THE Pycnodonts were the coral fishes of Mesozoic seas, with a deepened body, produced face, and a small mouth having grasping and grinding teeth, capable of obtaining their hard-shelled food from hollows and crannies. They are evidently not to be regarded as closely allied to any of the typical coral fishes of Tertiary and existing seas, which are spiny-finned teleosteans. They are merely *Lepidotus*-like and *Dapedius*-like forms with adaptations to a similar mode of life. The study of their skeleton is therefore of great interest.

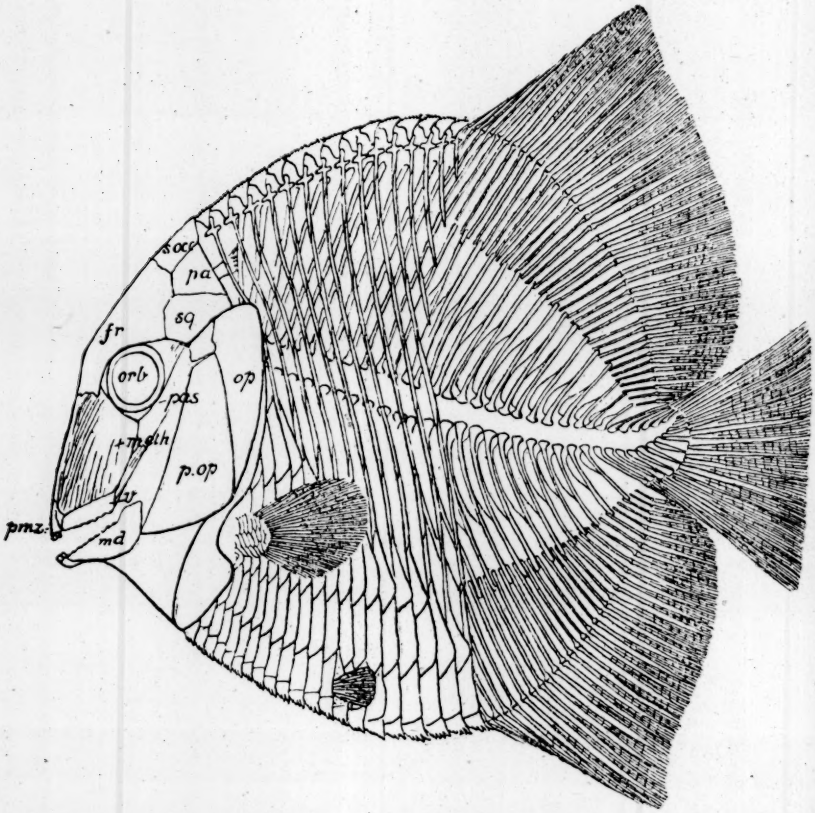
A complete summary of the osteology of the Pycnodonts, so far as known, was published in 1895–6[1]; and, following the observations of other authors,[2] I have since had many opportunities of pursuing the subject further. A detailed study of *Microdon radiatus* in the forthcoming part of the Monograph of Wealden and Purbeck Fishes for the Palæontographical Society has especially led me to review the whole group of Pycnodonts, and I now venture to publish a few supplementary notes which these researches have suggested.

The normal arrangement of the roof-bones in a Pycnodont skull is shown in the accompanying restoration of *Mesodon* (p. 386). An elongated unpaired plate—the so-called supraoccipital (*s.occ.*)—forms the median ridge behind, and completely separates a pair of plates which are commonly identified as parietals (*pa.*). Each of the latter seems to represent a true parietal fused with a supratemporal; for in *Microdon radiatus*, at least, it is clearly traversed behind by two parallel transverse slime-canals. The bone also bears at the middle of its hinder border a smooth process with digitate end, which passes

[1] A. S. Woodward, *Catalogue of Fossil Fishes in the British Museum*, pt. iii (1895), pp. 190–8; also "On some Remains of the Pycnodont Fish, *Mesturus*, discovered by Alfred N. Leeds, Esq., in the Oxford Clay of Peterborough": Ann. Mag. Nat. Hist. [6], vol. xvii (1896), pp. 1–15, pls. i–iii.

[2] D. G. Kramberger, "De Piscibus Fossilibus Comeni, etc.": Djela Jugoslav. Akad., vol. xvi (1895), pp. 18–34, pls. v–vii, fig. 1. E. Hennig, "*Gyrodus* und die Organisation der Pyknodonten": Palæontographica, vol. liii (1906), pp. 137–208, pls. x–xiii; also "Ueber einige Pyknodonten vom Libanon": Centralbl. für Mineral., 1907, pp. 360–71.

beneath the antero-dorsal scales, and may perhaps be regarded as the post-temporal. It is, at any rate, noteworthy that in *Gyrodus*, where separate supratemporals and post-temporals appear to be recognizable,[1] the parietal is exceptional in lacking the small posterior process. The otic region is completely covered by a squamosal plate (*sq.*).



Mesodon macropterus (Agassiz); restoration, with cheek-plates removed, about two-thirds nat. size. Upper Jurassic (Lithographic Stone): Bavaria. *fr.* frontal; *m.eth.* mesethmoid; *md.* mandible, showing narrow dentary in front; *op.* operculum; *orb.* orbit; *p.op.* preoperculum; *pa.* parietal; *pas.* parasphenoid; *pmx.* premaxilla; *s.occ.* supraoccipital; *sq.* squamosal; *v.* vomer. Drawn by Miss Gertrude M. Woodward, chiefly from a specimen in the British Museum (No. P. 5546).

The frontals (*fr.*), which meet in a median suture, are the largest bones of the roof, sometimes ending abruptly just in advance of the orbit, sometimes tapering along the upper edge of the mesethmoid element of the snout.

[1] E. Hennig, Palæontographica, vol. liii (1906), p. 143, pls. x, xi.

In *Mesodon*, *Microdon*, *Stemmatodus*, *Gyrodus*, and *Mesturus*, the roof-bones form a continuous shield; but in *Cœlodus*, *Pycnodus*, and perhaps *Palæobalistum*, there is a small supratemporal vacuity on each side, bounded in front by the frontal, mesially and in part posteriorly by the "supraoccipital", laterally and in part posteriorly by the "parietal". In the British Museum this vacuity is well seen in specimens of a new species of *Cœlodus* from the Lithographic Stone of the Montsech, Lérida, Spain (Nos. P. 10999, 11000), in *Cœlodus costæ* from Castellamare, Italy (Nos. P. 1671, 1671*a*), in the so-called *Palæobalistum ponsorti* (which is probably a species of *Pycnodus*) from Mont Aimé, Marne, France (Nos. 28292, P. 1638), and in *Pycnodus platessus* (No. P. 1633) and *P. gibbosus* (No. P. 1634) from Monte Bolca, Italy. It evidently corresponds with the supratemporal vacuity in the existing teleosteans of the family Zeidæ,[1] and implies that in the Pycnodont genera just mentioned the lateral muscles of the trunk extended slightly forwards over the cranial roof. The "supraoccipital" is therefore probably the foremost dorsal ridge-scale enlarged and displaced forwards, while the part of the "parietal" bounding the vacuity behind is really a supratemporal.

The delicate and toothless pterygoid arcade, which was first seen in *Anomœodus* and *Mesturus*, has now been observed both in *Gyrodus* and *Cœlodus*; but the nature of the palatine bone remains uncertain. In the tritoral dentition there is still no satisfactory evidence of successional teeth. There are usually only two prehensile teeth in each premaxilla and dentary; but both in *Gyrodus* and in *Mesturus* there are three or four teeth in the premaxilla, four in the dentary.

Although the dentition is obviously adapted for crushing hard skeletons, it is curious that no example of a Pycnodont has hitherto been described showing the contents of the stomach. There appears to be only one such specimen in the British Museum—a small individual of *Pycnodus platessus*, shown of the natural size in Plate XXIV. Here the distended stomach is filled with the comminuted remains of bivalved shells, which are ornamented with radiating riblets, but are too imperfect for determination.

In this connection it is interesting to notice that some of the Pycnodonts agree with the existing *Balistes* in possessing clusters of small claw-shaped pharyngeal teeth. These teeth, found isolated, are known to palæontologists under the name of *Ancistrodus*.[2] In the British Museum I first observed them in their natural position in specimens of *Cœlodus* from the Montsech, Spain (No. P. 10996). They are seen in nearly all specimens of *Palæobalistum ponsorti* from Mont Aimé, France, and in *Pycnodus platessus* from Monte Bolca, Italy (Nos. 41083, P. 4386). They also occur in the type-specimen of *Xenopholis carinatus* and in a new specimen of the latter species (No. P. 10700). Similar teeth are seen in front of the mandible of a specimen of *Xenopholis* in the Court Museum, Vienna; and five

[1] E. C. Starks, "The Osteology and Relationships of the Family Zeidæ": Proc. U.S. Nat. Mus., vol. xxi (1898), p. 471, pl. xxxiii.

[2] W. Dames, "Ueber *Ancistrodon*": Zeitschr. deutsch. geol. Ges., 1883, pp. 655–70, pl. xix. See also figure by A. Gaudry, *Les Enchaînements du Monde Animal.—Fossiles Secondaires* (1890), p. 167, fig. 263.

of them, sufficiently large to have been the premaxillary and dentary teeth, have been found with a group of tritoral teeth of *Acrotemnus* in the Chalk of Belgium.[1] Larger and stouter examples of "*Aneistrodus*", therefore, are probably the prehensile teeth of Pycnodont jaws;[2] but the smaller examples, with translucent or transparent enamel, belong to the pharyngeal dentition.[3]

In *Cœlodus* the preoperculum is subdivided by an irregular transverse suture into two portions, the lower being the larger. The vertical slime-canal, which always traverses the preoperculum in Pycnodonts near its anterior border, passes directly into the upper portion, thus proving that it is not the operculum, as it has been named by Kramberger,[4] and also by Bassani and D'Erasmo.[5] The operculum in *Cœlodus* resembles that of other typical Pycnodonts, and the same bone in *Stemmatodus* is figured by Bassani and D'Erasmo[6] as a supraclavicle.

The ribs in Pycnodonts are comparatively short, extending not more than half-way to the ventral border. Each bears a paired laminar expansion tapering distally, as well seen in a specimen of *Gyrodus* in the British Museum (No. P. 1623*a*).

In the pectoral arch the supraclavicle has now been clearly observed in *Microdon radiatus* from the Purbeck Beds. Its exposed upper portion, crossed by the slime-canal, is triangular in shape, and its apex is situated at a short distance below the posterior process of the parietal bone.

In the typical *Mesodon* (Figure on p. 386), as in most Pycnodonts, the flank-scales are complete only in the lower part of the abdominal region, beginning with four or five in the transverse row immediately behind the pectoral arch and gradually diminishing to two or three in the last row just in front of the anal fin; the uppermost scale in each row tapering upwards to its riblet. In some of the earlier species commonly referred to *Mesodon*, however, such as *M. liassicus*, the scales are complete throughout nearly all the transverse rows; and I unfortunately made the mistake of representing this type of squamation in my first restoration of *M. macropterus*,[7] which is now corrected. In those genera in which the squamation is more or less nearly complete, either over the whole or the front half of the trunk, the scales are less deep and more numerous than in the genera in which the squamation is much reduced.

In nearly all Pycnodonts the ventral ridge-scales occur in uninterrupted series, and the small pelvic fin on each side is inserted

[1] M. Leriche, "Un Pycnodontoide aberrant du Sénonien du Hainaut": Bull. Soc. Belge Géol., vol. xxv (1911), Proc.-Verb., pp. 162–8, pl. A.

[2] e.g. specimen figured by A. S. Woodward, *Fossil Fishes of English Chalk* (Mon. Pal. Soc., 1909), pl. xxxv, fig. 8.

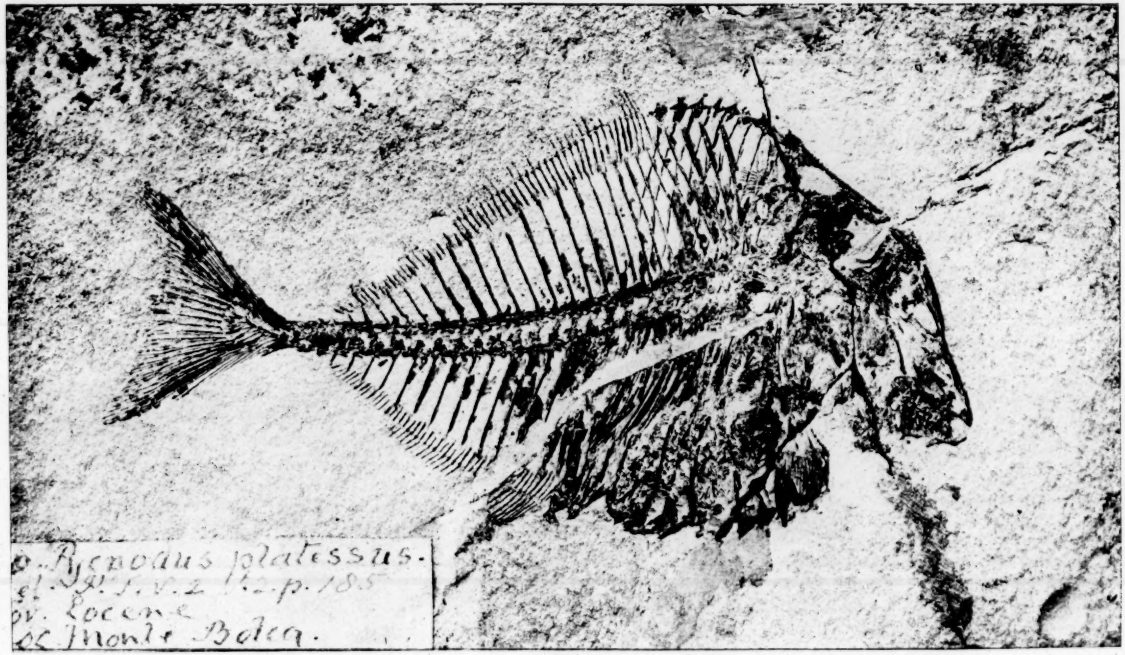
[3] e.g. specimen figured by A. S. Woodward, Proc. Geol. Assoc., vol. x (1888), pl. i, fig. 10.

[4] D. G. Kramberger, Djela Jugoslav. Akad., vol. xvi (1895), pp. 21, 31, pls. v, vi.

[5] F. Bassani & G. D'Erasmo, "La Ittiofauna del Calcare Cretacico di Capo d'Orlando presso Castellammare (Napoli)": Mem. Soc. Ital. Sci. [3], vol. xvii (1912), p. 227, fig. 12.

[6] Loc. cit., p. 221, fig. 9.

[7] A. S. Woodward, *Vertebrate Palæontology* (1898), p. 105, fig. 74.



PYCNODUS PLATESSUS, AGASSIZ. U. EOCENE, MONTE BOLCA, ITALY.

just above them. In most cases the two transverse rows of scales diverge at their lower end to admit the insertion of this fin and the intercalation of one scale behind it. One ventral ridge-scale at this point thus bears two facettes, one for its corresponding normal flank-scale, one for the intercalated scale. In *Pycnodus* and the so-called *Palæobalistum ponsorti*, one transverse row of scales seems to bifurcate at its lower end to accommodate the pelvic fin, and there is a gap in the ventral ridge-series immediately beneath it. The position of the anus is uncertain.

It is interesting to add that both in *Mesodon* and *Microdon* one or perhaps two small rhombic ganoid scales remain on the upper caudal lobe.

As to the systematic arrangement of the Pycnodonts, it is clear that the earliest species usually referred to *Mesodon* are the most primitive. I have placed them in a distinct genus in the forthcoming part of my *Monograph of Wealden and Purbeck Fishes*. *Gyrodus* and *Mesturus* are closely related to each other and diverge in several respects from other members of the group. The well-armoured Cretaceous forms, *Coccodus* and *Xenopholis*, are also peculiar. The general trend of specialization in the family seems to be as already stated in the British Museum Catalogue of Fossil Fishes.

EXPLANATION OF PLATE XXIV.

Pycnodus platessus, Agassiz; photograph of nearly complete fish in limestone, showing a mass of comminuted shells within the abdominal region. Nat. size. Upper Eocene: Monte Bolca, near Verona, Italy. British Museum, No. P. 1633.

II.—Morphological Studies on the Echinoidea Holectypoida and their Allies.

By Herbert L. Hawkins, M.Sc., F.G.S., Lecturer in Geology, University College, Reading.

V. The Perignathic Girdle of *Discoides cylindricus* (Lamarck).

(PLATE XXV.)

1. Introduction.

P. M. DUNCAN, to whose work we owe the standardization of our knowledge concerning the ambulacral structures of the Echinoidea, published in 1885[1] a memoir "On the Perignathic Girdle of the Echinoidea", in which he definitely established the principles whereby this apparatus may be described and put to taxonomic use. The actual term "perignathic girdle", first introduced in that paper, was given with direct reference to the "perfect girdle around the jaws in *Discoidea*" (l.c., p. 207), although no detailed account of the peristomial structures of that genus was included. In the following year the same author, in collaboration with W. P. Sladen, gave a full description of the girdle of *Discoides*, in the light of the results reached in the previous work. The same two authors practically repeated their opinions on this topic in a later paper published in 1889.

[1] See list of literature at the end of this paper.

In 1884, in this Magazine, Duncan, to use his own words, "enlarged upon the nature of the peristomial structure of *Galerites albogalerus*" (*Conulus*), and proved, at least to his own satisfaction, that neither jaws, teeth, *nor perignathic girdle*, were developed in that species. To this opinion he and Sladen adhered in 1889.

During the same period Lovén had turned his attention to the perignathic structures of the Holectypoida, and published the results of his researches in 1888 in the course of his paper on the (probably misleading) discovery of *Pygastroides relictus*. In respect of the perignathic girdle of *Discoides*, Lovén's observations led him to conclusions as to its structure which were diametrically opposed to those of Duncan and Sladen in practically all features of importance. He also expressed the belief that both *Discoides* and *Conulus* were furnished with lanterns and teeth. To this Duncan and Sladen replied in 1889 by a regrettably dogmatic paper in which they repeated their previously expressed views, after the examination of a new series of specimens. Again they stated that the girdle of *Discoides* was composed wholly of interambulacral structures (ridges); that *Conulus* had no girdle at all, or at most a degenerate and functionless ridge; that it was extremely improbable that *Discoides* had any jaws; and, by inference, that it was practically certain that *Conulus* was totally devoid of a lantern. In 1892 Lovén published a fuller account of the girdles of the two genera, and, either in charity or sarcasm, referred to the work of the two British authors in a footnote only, without comment. He also had the intense satisfaction of being able to describe the pyramids of the lantern in *Discoides*.

Since the period of this somewhat strained, but eminently courteous, controversy, the present writer has published a more complete account of the lantern and teeth of *Discoides* (1909), and has recorded the discovery of indubitable teeth in *Conulus subrotundus* (1911). For the rest, the question of the characters of the perignathic girdle in the two genera remains practically in the unsatisfactory condition in which it was left.

The difference between the two interpretations of the girdle of *Discoides* can be best understood by a comparison of the figures given by the respective authors. If, following the advice of Duncan, we "very respectfully draw our . . . attention to [Lovén's drawing], fig. 2" (here partly reproduced in outline on Pl. XXV, Fig. 2), we find that each sector of the girdle is composed of four vertically elongated plates, the outer pair of which is united to the ambulacra by suture, while the inner pair articulates with three small polygonal plates on the interambulacral margin of the peristome. The outer pair consists of "processes" in Duncan's terminology, while the inner pair, with the three small plates, constitutes the "ridge". On comparing this drawing with Duncan & Sladen's very diagrammatic sketch (here copied in part, Pl. XXV, Fig. 1), the only discrepancies to be noticed are in the absence of the median interambulacral suture and of the small plates, and in the straightness of the sutures at the bases of the processes. (With the position of the ambulacral pores, another point of difference, we are not now concerned.) But the interpretation

of their diagram given by the last-named authors affords a most striking contrast with that which must inevitably apply to Lovén's drawing. They maintained that the straight suture which comes at the adradial base of the projecting part of the girdle was the "interradio-ambulacral" (adradial) suture, and that the three large constituents of the girdle were all wholly interradial in position.

Two such opposite interpretations of a superficially straightforward structure demand reconciliation. The chief purpose of this paper is to show how this reconciliation can be effected. In the next paper of this series a new reading of the girdle of *Conulus* will be given (the denial of the presence of this structure is a lamentable and inexplicable lapse on the part of Duncan & Sladen), together with a general summary of the characters of the perignathic girdle in the Order. I hope to publish a comparison of the girdles of the Holectypoida and Clypeastroida at an early date, at the same time discussing the homologies of the peristomial structures of the Spatangoida.

2. The Perignathic Girdle of *Discoides cylindricus*.

(a) *Duncan & Sladen's Interpretation.* (Pl. XXV, Fig. 1.)

The outstanding characters of the perignathic girdle as represented by this diagram are: firstly, the presence of a low, thickened margin to the peristome in the ambulacral regions, perforated by three pore-pairs in each area; and secondly, the development of smooth, sloping ridges on the interambulacral margins, each composed of three flat plates, of which the central one is large and roughly rectangular in shape, while the outer (adradial) two are narrow adorally, expanding distally into prominent "ears". There is nothing inherently improbable in the ambulacral part of the girdle, for it would prove to be in a slightly modified Cidaroid stage of development. But the existence of three plates, representing three columns, in the interambulacra, would be a most extraordinary anomaly. It is true that in the somewhat obscure *Tiarechinus* and *Lysechinus* from the St. Cassian Beds of the Trias, the interambulacra are believed to show three columns (represented by one plate each) above the primordial, but to find such a feature in *Discoides*, especially when the rest of the interambulacra are built of the normal two columns, would be indeed marvellous. Even if the large central plate of the ridge be regarded as the primordial, and the two plates at the sides as the first two paired plates of the area, the figure becomes only less grotesque.

A comparison of the figure with a prepared specimen shows that the former is, as regards its drawing, a fair, though diagrammatic, representation of the appearance of the girdle. But the sutures near the ambulacral pores are not so straight as Duncan & Sladen make them, and the lateral "eared" plates of their ridge are certainly based upon the proximal ambulacral plates. There can be no possible doubt that their "interambulacro-radial" suture is really the basal suture of the process. The two "eared" lateral plates of the ridge are therefore certainly processes, as Lovén maintained. The true ridge, stripped of its radial

marginals, would then be left as a flat, sloping plate of large size. This is certainly its general appearance in a specimen, but with careful lighting it may be found that the ridge plate is not flat but has a marked central concavity and several small irregularities on the exposed face. Its free (distal) margin is never, so far as I have determined, so straight as in the figure, and there is always a decided change in the direction of that margin when the processes are reached. But unless this large ridge represents simply the primordial interambulacral plate (which is almost inconceivable) it must necessarily be compound, and be crossed by sutures vertically or transversely or both. Duncan & Sladen expressed surprise at the apparent absence of sutures, but seem to have been satisfied that they were not present in the specimen from which their diagram was drawn. Their remarks (l.c., p. 237) imply that they were prepared to believe that sutures might exist in the ridge in some specimens and not in others. Such variability would be contrary to all experience in Echinoid structure, and one can only believe that their specimen was unsuitably preserved or cleaned for the display of the sutures.

To sum up: the lateral lappets of the ridge in Duncan & Sladen's diagram are in reality processes, and there is every reason to believe that the lack of sutures in the broad median plate is due to incomplete observation.

(b) *Lovén's Interpretation.* (Pl. XXV, Fig. 2.)

The beautiful figure published by Lovén in 1888 was copied by him in 1892, with the addition of another in which no sutures were shown. The twice published figure (here copied) was taken from the girdle of a depressed form of *D. cylindricus*, while the other represented a modification of the processes which Lovén thought to be restricted to the elevated, cylindrical form. Lovén suggested that the striking diversities between the superficial aspects of the two girdles might imply a specific difference between the two forms. In 1909 I showed that the "*forma elatior*" type of girdle could be found in specimens of the "*forma vulgaris*" (or "*depressa*"), and subsequent observations have confirmed this. The difference between the two types consists in the greater prominence of the processes in the "*forma elatior*" and in their inappreciable elevation beyond the apex of the ridge in the depressed form. This would appear to be a modification due solely to the size (i.e. age) of the specimen. The occurrence of the two kinds of girdle in the same form in no way vitiates the possibility of there being two distinct varieties of the species; on the contrary, it makes it the more probable that the two forms are definitely distinct. While the largest specimens of *D. cylindricus* that I have seen are all of the "*forma elatior*", I have examined numerous specimens of the "*forma vulgaris*" which were much larger than many decidedly cylindrical examples.

To turn to an analysis of the figure here copied: The outline of the girdle is for all practical purposes similar to that shown in Duncan & Sladen's figure. But the sutures at the bases of the processes are represented as curved, somewhat irregular lines, while

the "lappets" of the processes, and indeed the whole ossicles, are shown to overlap the poriferous zones of the ambulacra. The central portion, or true ridge, of each section of the girdle is divided into two main sections by a more or less median suture, and at the margin of the peristome there are three small, unequal and irregularly shaped plates. In two of the areas, Nos. 4 and 5, Lovén, with his customary faithfulness to observation, has indicated some of the sutures in the ridges by broken lines, thus proving that in the other areas he could clearly distinguish the outlines of the plates. (No sutures whatever, either in the girdle or on the adoral surface of the test, are drawn in his figure of the "*forma elatior*", which was evidently a fully grown specimen in which secondary thickening had covered the original surfaces of the plates.) In one of the many preparations of the girdle of *Discoides* that I have made, there is a distinct median suture in some of the ridges, and fairly convincing evidence of the existence of a small triangular plate in the middle line at the peristomial border. By means of thin sections examined under crossed nicols, I have been able to confirm the presence of this small plate. I have not succeeded in tracing the two small plates which Lovén figures on each side of the median one; but the fidelity of his observations is so uniform that there can be no reasonable doubt of their occurrence, in some examples, at least. Lovén's drawing differs from that of Duncan & Sladen in these two fundamental points only: it is a faithful copy, not a diagram, and it contains a record of more complete observation. In its essential features I can confirm its accuracy from original observation. It is perhaps worth remarking that I made sketches which agree with Lovén's figure (with the exception noted above) before I had adequately studied his drawing. In the detection of sutures, particularly where they are faint and of unusual distribution, it is distressingly easy to be influenced by preconceived ideas. On re-examining my specimens after becoming familiar with Lovén's rendering, not only do the sutures previously detected seem far more obvious than before, but it is quite possible to imagine the presence of the two small plates on either side of the median one at the peristomial margin. However, experience has made me so wary in these matters that I have failed to convince myself of the certain occurrence of the sutures which would be the boundaries of such plates. That they were patent in Lovén's specimen I fully believe.

(c) *A suggested new interpretation.* (Pl. XXV, Figs. 3 and 6.)

In spite of the doubts entertained by Duncan & Sladen, there is no difficulty in recognizing the processes in the girdle of *Discoides*. Separated from the ridges, they present a marked similarity to those of *Plesiechinus* (see part iv of this series). It is in the ridges, which were hardly developed in the Jurassic Holectypoida, that the peculiarity occurs. The primordial interambulacral plate is generously represented at the peristomial margin in all five areas in *Discoides* (see Lovén, 1872, pl. xiv, fig. 125). In the majority of those Diademoida which have a strongly developed ridge, this

structure is composed of a varying number of paired interambulacrals at its base, and has an apparently undivided plate along its free margin (see Duncan, 1885). It is possible that this unpaired plate may represent the primordial interambulacral (which is absent from the peristomial margin in these forms); or perhaps an outgrowth from it prior to its resorption. But in *Discoides*, where the primordial plate is situated on the peristomial margin, the distal part of the ridge is definitely composed of paired plates.

In *Plesiechinus* the only representative of the ridge is found as a semilunar inward prominence of the primordial interambulacral. It is, as far as my observations indicate, and as would be expected from its position, absolutely undivided by sutures of any kind. In *Discoides* the small median peristomial plate of the ridge is slightly, but definitely, more prominent than the rest of the structure. It is, almost certainly, the inner surface of the primordial plate. This small portion of the ridge must therefore be the homologue of the "ridge" of *Plesiechinus*.

In the Cidaroida and Diademoida the ridge is only connected to the normal coronal plates at its base, projecting almost vertically from their horizontal inner surfaces. In *Discoides*, on the contrary, the whole ridge, with the exception of an almost negligible rim at its distal extremity, is recumbent upon the interambulacrum, which is thickened so as to project in some cases (in internal aspect) to a greater height than the ridge itself attains. (See Pl. XXV, Fig. 3.) The degree to which the ridge extends above its supporting plates varies considerably, apparently with age. In some forms, where the radiating buttresses are low and feeble, the projection of the ridge may amount to nearly half its total height. It will be noticed in Lovén's figure (my Pl. XXV, Fig. 2) that the median suture of the ridge is directly continuous with that of the normal part of the interambulacrum. These distal plates of the ridge of *Discoides*, which constitute the greater part of the ridge, surely represent the inner surfaces of the paired interambulacrals next to the primordial, modified as supports, perhaps as actual "slides", for the inclined lantern. The projecting rim of the "ridge" need cause no surprise when the extraordinary pillar-like and carinate internal developments of the inner surface of the Clypeastroida, and indeed of *Discoides* itself, are taken into account.

If this interpretation of the girdle is correct, it follows that the girdle proper consists of the paired processes and small triangular peristomial plate of the interambulacrum; and that the bulk of the ridge is merely a specialized portion of the thickened paired plates. There is then no difficulty in considering the two small lateral plates of Lovén's figure, which form the interradial sides of the branchial incisions, as the first paired columnals; while the two large upper plates represent the somewhat expanded and modified inner surfaces of the second pair. All of the "ridge" except that part built of the small proximal median plate, is then not homologous with the ridge of a Diademoid. I would call it a "*false ridge*". It serves, like the buttresses recently described in *Plesiechinus*, as a mechanical support for the processes; and has the additional function of

providing a smooth, slippery surface on which the splayed pyramids of the lantern could recline.

(d) *The position of the jaw-muscles.* (Pl. XXV, Fig. 6.)

There is a clearly defined articular facet on the upper part of each process which undoubtedly served for the attachment of the retractor muscles. I have failed to find any other indications of muscle-attachments upon the processes; and, to judge from the known characters of the pyramids, it seems improbable that a second pair of retractors was present.

The position of attachment of the protractor muscles is less clear. In those Clypeastroida which have paired processes, the protractors arise from the interradial sides of the processes, usually at or near their bases. Such a position for the protractors is quite impossible in *Discoides*, since there are no "interradiad faces" to the processes owing to the great height of the "false ridges". Hence the protractors must have been attached to some part of the ridge or "false ridge"; that is, in the Diademoid manner. I have not been able to recognize any muscle-impressions on the interradial parts of the girdle. Clearly the broad, shallow, elliptical depression which occupies most of the surface of the false ridge is not a muscle-scar. In some specimens there are very small and inconspicuous knobs on the false ridge at the upper corners of this central depression. They do not, however, suggest muscle-attachments, since these are normally roughened and depressed in Echinoid girdles. There remains the somewhat prominent "true ridge", on the actual margin of the peristome. If the interpretation of the girdle given above is correct, this is the proper situation for protractor attachments, by analogy with the Diademoida. It will be seen that in Pl. XXV, Fig. 6, I have based these muscles upon this median thickened plate. A further reason for this reconstruction—one that seems to me to be very cogent—is the normal direction of the protractor muscles. These, in the Diademoida, pass almost vertically from the low ridges to the tops of the hemi-pyramids. Owing to the prominence of the true ridge in *Discoides*, such a muscle arising from it would have free play for a considerable distance in all directions (see Pl. XXV, Fig. 6). Owing to the concave curvature of the rest of the "ridge", the only other position from which similar freedom could be attained would be the actual crest—a most unlikely place for the attachment of a strong muscle.

There is no evidence for the existence of radial compass muscles, nor of compasses in the lantern. Although negative evidence, when concerned with structures of such delicacy, is utterly unreliable, I have omitted them from the restored figure in view of their proved absence in the Clypeastroida. If it should be shown that *Discoides* had compasses, I should incline to find the attachment of their muscles on the true ridges between the pairs of protractors.

(e) *The nature of the "false ridges".*

If the foregoing argument respecting the position of the muscle-attachments of the perignathic girdle of *Discoides* is accepted, the interradial portion that I have called the false ridge is seen to be

divorced from the true girdle as regards function. That it serves as a useful support for the very slender processes is obvious; and that it consists of the bevelled and otherwise modified edges of the very thick proximal coronal plates seems equally clear. In the previous article in this series (GEOL. MAG., August, 1917), I showed that the processes of *Plesiechinus* are supported by thick buttresses which are built almost wholly of thickened interambulacral plates. The buttresses of the Jurassic genus are so similar in character, though far different in extent, to the carinate thickenings of the adoral surface of *Discoides*, that it is practically certain that the latter structures represent a phylogenetically later stage of the former. The buttresses of *Plesiechinus* pass towards the median interradial lines after leaving the processes, and subsequently return to the neighbourhood of the adradial sutures. In *Discoides* (see Pl. XXV, Fig. 3) they may be said to have a similar course, but each pair converges interradially to such a degree that fusion results. Thus the whole proximal part of each interambulacrum becomes much thickened, although elsewhere on the adoral surface the test is extremely thin. The false ridge therefore represents the bevelled edge of the fused buttresses.

Nevertheless, the false ridge is a more specialized structure than the preceding conclusion would demand. It is of closer texture than the ordinary parts of the buttresses, projects to a varying distance above them, and is hollowed in the centre. Clearly it must have served some special function, for which these characters are adaptations.

The strongly inclined (almost horizontal) pyramids of the lantern of *Clypeaster* actually articulate with the processes. There are no buttresses or analogous supports in the immediate vicinity of the peristome in this type. The lantern of *Discoides*, as Lovén and I have described it, was evidently "flaring" in character, though far more nearly vertical than is the case in *Clypeaster*. Since pyramids are interradial in position, it follows that they would lean over the proximal interradial plates, if splayed outwards. In *Discoides* these plates are much thickened; hence they must be bevelled off so as to afford play for the pyramids. It is at least likely, by comparison with the closely related Clypeastroida, that the pyramids may have actually leaned against the bevelled edges (false ridges) when the jaws were closed. This would be a preliminary to the actual articulation found in the last-named group. It may therefore be suggested that the smooth, concave surfaces of the false ridges served as "slides" for the pyramids, allowing them to be drawn up or down according as the teeth were withdrawn or extruded; and preventing the strain which would inevitably fall upon the muscles holding an inclined lantern together. The hollowing of the adoral faces of the false ridges would, as shown above, allow freedom of action for the protractor muscles.

3. SUMMARY.

The conclusions of Lovén as to the composition of the perignathic girdle of *D. cylindricus* are confirmed in essential particulars, while

FIG. 1.

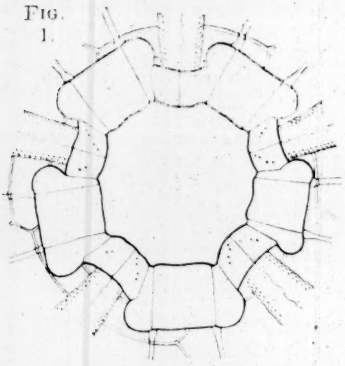


FIG. 2.

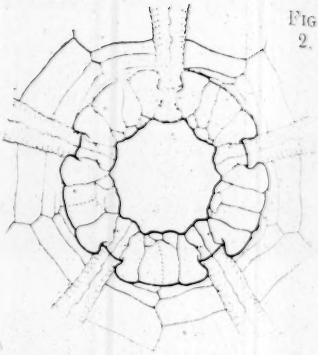


FIG. 3.

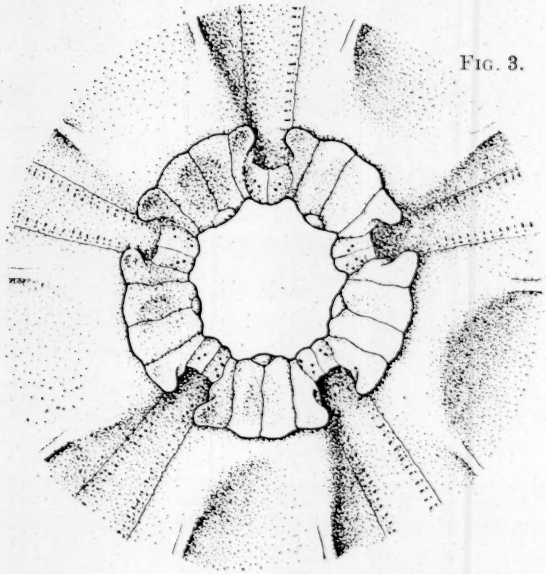
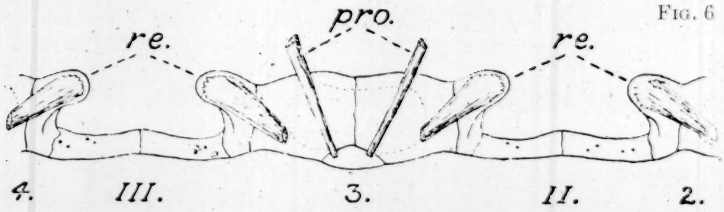


FIG. 4.

FIG. 5.

FIG. 6



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PERIGNATHUS GIBBUS, sp. DISCOIDUS, CYLINDRICUS, sp. nov.

those of Duncan & Sladen are shown to be based upon imperfectly preserved material. The processes, which may project freely for a varying distance above the rest of the girdle, are slender. The actual ridges are represented, as in *Plesiechinus*, by the slightly thickened and projecting inner surfaces of the unpaired primordial interambulacral plates. The rest of the interradial portion of the girdle is interpreted as being made of the bevelled edges of the buttresses which radiate over the interambulacra of the adoral surface. These sloping surfaces, here called "false ridges", are believed to be specialized and somewhat extended as "rests" or "slides" for the inclined pyramids; thus forecasting the articulation between lantern and girdle found in the Clypeastroida. The retractor muscles were attached to the upper parts of the processes, and it is argued that the protractors must have sprung from the small true ridges, the false ridges having no function as muscle supports. In the absence of positive evidence, radial compass muscles are presumed to have been absent.

4. List of Papers consulted.

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—— & Sladen (W. P.). 1886. "On the Anatomy of the Perignathic Girdle of *Discoidea cylindrica*": Journ. Linn. Soc. Zool., vol. xx, pp. 48–61.

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Lovén (S.). 1872. "Études sur les Échinoidées": K. Svensk. Vet.-Akad. Handl., Bd. xi, No. 7.

—— 1888. "On a Recent Form of the Echinoconidæ": Bih. K. Svensk. Vet.-Akad. Handl., Bd. xiii, Afd. iv, No. 10.

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EXPLANATION OF PLATE XXV.

Fig.

1. Copy of the figure of the perignathic girdle of *D. cylindricus* given by Duncan & Sladen (1889). The inner part of the figure, slightly reduced.
2. Copy of the figure of the perignathic girdle of *D. cylindricus* given by Lovén (1892). The inner part of the figure, slightly reduced; outline only.
3. The perignathic girdle of *D. cylindricus* (original). The figure is diagrammatic in that the sutures in the ridges were only seen in three of the areas, and the sutures of the coronal plates are omitted. The ridges project very little above the fused buttresses. The processes are intermediate in character between those of the "*forma vulgaris*" and "*forma elatior*" of Lovén. The specimen is depressed hemispherical in shape. The small true ridge is not quite so prominent as represented.
4. Section through the interradial line of the girdle of a specimen in which the ridge is unusually prominent, owing to the feeble development of the buttresses.

Fig.
5. Corresponding section of a specimen like that shown in Fig. 3; the ridge hardly projecting above the buttresses.
6. Diagram of the probable disposition of the jaw-muscles: *re.* retractors, *pro.* protractors. The radial compass muscles are omitted, being probably absent. The concavity of the false ridge is indicated by a dotted line. The girdle is shown from the oral view, so that the height of the processes and ridges is made to seem less than the actual by perspective due to their inclined character.

III.—Evidence suggestive of Charnian Movement in East Kent.

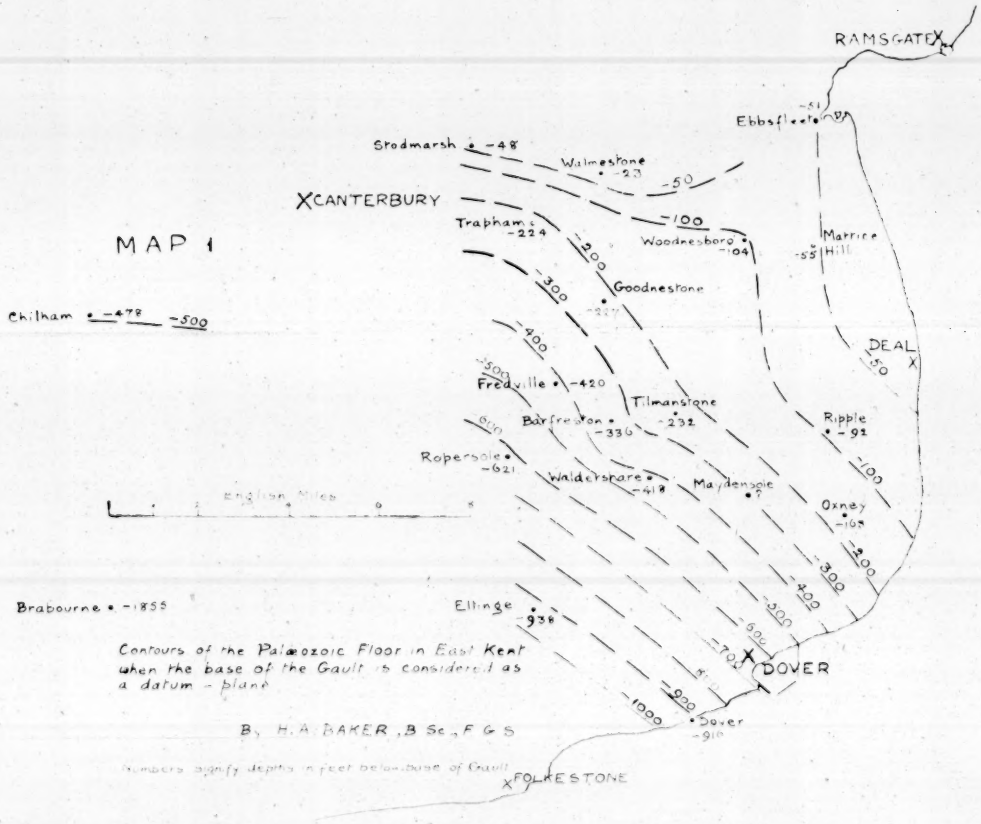
By Herbert Arthur Baker, B.Sc., F.G.S.

(WITH TWO MAPS: PLATES XXVI AND XXVII.)

A COMPARATIVE study of the whole of the evidence concerning the Palæozoic floor beneath the South-East of England and the manner in which the various members of the Mesozoics are disposed upon it has led the present writer to conclude that the area, originally defined by Professor P. F. Kendall,[1] over which the effects of the operation of a "posthumous" Charnian axis may be discerned, can be greatly extended, more particularly to the eastward. The evidence, indeed, strongly suggests the presence of a second Charnian axis beneath Suffolk, proceeding thence south-eastward to North France.

East Kent lies on the western flank of this alleged Charnian ridge, and in view of the greater abundance of deep borings there, furnishes the best area in which to study its influence upon both the Palæozoic and Mesozoic rocks. With regard to the former, all the steadily accumulating information concerning the structure of the South-Eastern coalfield points to the presence, eastward of Kent, of a ridge or barrier of a Charnoid or Malvernoid trend, which appears to have been a potent factor during the deposition of the Kentish Carboniferous, and which probably now separates the coalfield from that of the Pas-de-Calais. In Kent the Lower Coal-measures, in the strict sense, are absent, and have apparently never been deposited, and there is no sign of Millstone Grit. The Middle Coal-measures lie unconformably upon the Carboniferous Limestone. The latter has been reached in several borings, particularly in North Kent, since the general dip of the Carboniferous in Kent is to the south-west. There is an area, a little to the north of Ebbsfleet, where, beneath the "blanket" of Mesozoic strata, the Carboniferous Limestone emerges from beneath the Coal-measures. For some five or six miles to the south-west of this zone of Carboniferous Limestone, the surface of the Palæozoic floor in East Kent is occupied by a succeeding "outcrop" of Middle Coal-measures, and these in their turn are succeeded by the Transition Coal-measures which cover the remainder of the surface of the known coal-basin to the south and west, to and beyond Dover. The general strike of the strata in the field is about 30° S. of E. and N. of W. A tendency of both Middle

[1] Kendall, "Sub-Report on the Concealed Portion of the Coalfield of Yorkshire, Derbyshire, and Nottinghamshire": Final Report Royal Comm. Coal Supp., pt. ix, 1905.


MAP 1
RAMSGATE
Ebbsfleet
Stodmarsh -48
Walmestone -23
CANTERBURY
Trapham -224
Woodnesborough -104
Matrice Hill
Goodnestone -227
Chilham -478
DEAL
Fredville -420
Tilmanstone -232
Barfreston -336
Ripple -92
Ropersole -621
Waldershare -418
Maydensole ?
Oxney -16
Brabourne -1855
Elmge -938
DOVER
Dover -910
FOLKESTONE
-50
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
English Miles
Contours of the Palæozoic Floor in East Kent when the base of the Gault is considered as a datum - plane
B. H. A. BAKER, B.Sc., F.G.S.
Numbers signify depths in feet below base of Gault

and Transition Measures (but particularly the latter) to thin in an easterly direction has been observed.[1]

The present contours of the Palæozoic floor in East Kent must differ considerably from those presented by it during the time of the encroachment upon it of the Lias and Oolites. This is in consequence of the severe post-Jurassic earth-movements which have affected the South-East of England. The most important of these movements occurred in post-Cretaceous times, and that which had the greatest effect upon the Palæozoic floor was the one which resulted in the uplift of the Weald. Its chief effect upon the old floor in East Kent was to decrease very considerably the south-westerly slope. Considering, for example, the average downward slope of the Palæozoic floor from Ripple to Ellinge, it is now seen to be about 51½ feet to the mile, whereas in pre-Cretaceous times it must have been more than 110 feet to the mile. Consequently, in considering the disposition and variation in thickness of the members of the Mesozoic cover in relation to the old floor upon which they successively encroached, it is necessary to have some idea of the form of the latter as it was during the time of the deposition of these Mesozoics. Map 1 (Plate XXVI) is inserted here in which an attempt is made to eliminate the effects of post-Lower Cretaceous movements from the Palæozoic floor by considering the base of the Gault as a datum-plane and drawing a system of lines through points on the floor at equal depths below it.[2] This method naturally suffers from the imperfections of artificiality, and, of course, gives only an approximation to the true pre-Upper Cretaceous contours of the floor, since no allowance has been made (nor, in the circumstances, can be made) for the variation in depth of the Gault sea; but, speaking generally, the chief error involved is that the south-westerly slope of the floor appears somewhat less than it must actually have been. The point, however, is one of no importance for our present purpose.

The map shows very clearly indeed that in pre-Cretaceous times the Palæozoic floor of East Kent was part of the western flank of an elevated ridge lying to the north-east of the Ebbsfleet–Deal area, and possessing a distinctly N.W.–S.E. trend. Westward, however, the influence of the ridge is seen to die out. The contours present one or two features of special interest. The lines do not everywhere accord with those of a peneplain, but suggest, rather, immature denudation, or, at any rate, interruption and readjustment of the conditions under which denudation was progressing, by a movement of uplift in the north, probably accompanied by faulting, along a new and discordant line, viz. roughly east and west. An interesting subsidiary ridge or spur (or disturbance) crossed the area, entering Kent in the neighbourhood of Deal and dying out near Ropersole.

Turning now to the consideration of the features presented by the Jurassic strata in proximity with this N.W.–S.E. ridge, we find abundant evidence not only of the existence of the ridge in Jurassic

[1] Newell Arber, Trans. Inst. Min. Eng., vol. xlvii, pt. v, pp. 677–724, 1914.

[2] See Table I, p. 402, at end of paper.

times but also of the occurrence along it of repeated movements of uplift, in fact "posthumous" movements. It is significant, too, that the series of disturbances which can be traced is in remarkable agreement with the movements cited by Professor P. F. Kendall[1] as having occurred along the line of his celebrated Charnian axis. In the East Kent Jurassics illustrations may be noted of practically every kind of evidence that superincumbent strata can yield concerning the proximity of an axis of instability. The detailed account of the Jurassic succession in the deep borings at Brabourne and Dover, given in a Survey memoir,[2] is most interesting from this point of view. At Brabourne, although Lower, Middle, and Upper Lias are represented, the total thickness is but 140 feet, and at Dover, although all three divisions apparently still occur, the total thickness of the formation has dwindled to less than 40 feet. At several horizons planes of erosion occur, and rolled fragments, nodules, and broken fossils are abundant.

It is to be regretted that similar detailed accounts of the Lias proved in some five or six other deep borings in East Kent are not as yet available. At present we have little more than the recorded thicknesses to work upon (and even these sometimes differ where more than one record exists), and so many different circumstances combine in affecting the thickness of a deposit that, in general, it would be scarcely safe to base any definite conclusions on it alone. Nevertheless, in the present case, the tracing of isopachyte systems in the Jurassic strata of East Kent (Map 2, Plate XXVII) results in a series of lines revealing the closest sympathy with the pre-Upper Cretaceous contours of the Palæozoic floor and bringing out clearly the north-easterly encroachment of the Mesozoics upon the subsiding ridge.

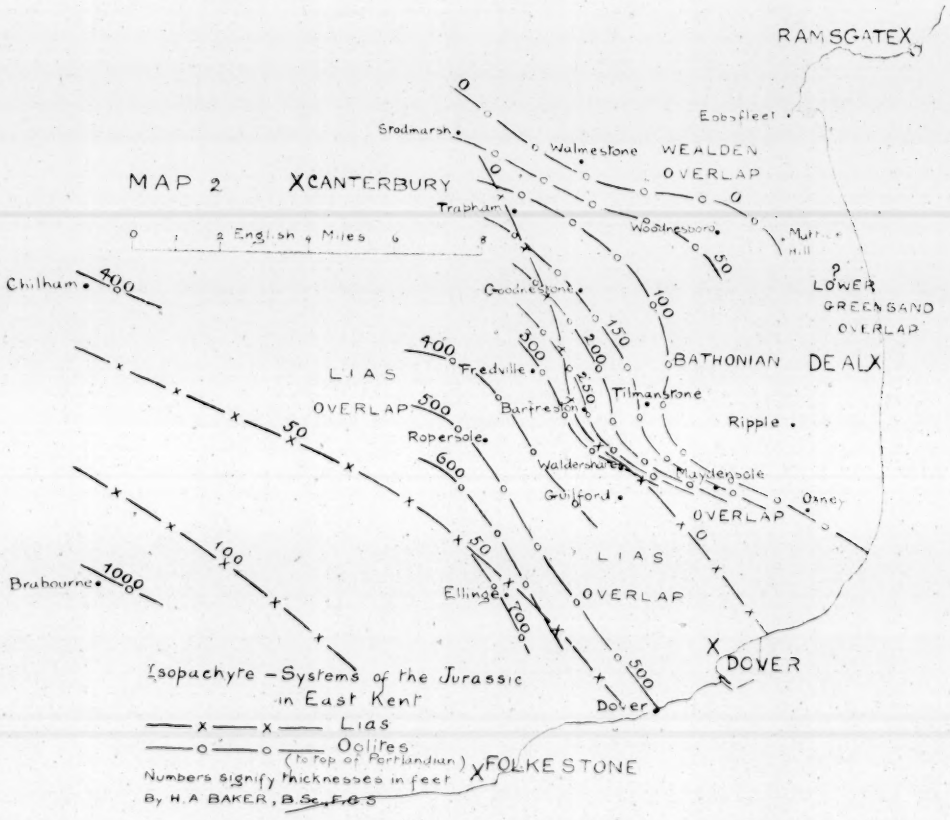
In the case of the Lias the evidence[3] is sufficient for the insertion of three isopachytes, viz. 0 (feather-edge of formation), 50 feet, and 100 feet. We see that with proximity to the easterly ridge the isopachytes reveal a marked tendency to take on a N.W.–S.E. trend. The influence of the Deal–Ropersole elevation upon the 0 isopachyte of the Lias is interesting.

Passing to the Oolites we have more data to work upon and the results are still more interesting. What detailed information we possess concerning the Oolite succession in the borings, adds to the evidence in favour of posthumous movement along the easterly ridge. At Dover, as in Kendall's area, there is a marked non-sequence between the Oolites and the Lias. The Inferior Oolite, which undergoes a remarkable attenuation in Northamptonshire, and becomes more and more sandy as the Charnian axis is approached, is doubtfully represented at Dover by less than 30 feet of calcareous sandy grit and clay, and at Brabourne by about 40 feet of muddy,

[1] Kendall, loc. cit.

[2] Lamplugh & Kitchin, *On the Mesozoic Rocks in some of the Coal Explorations in Kent* (Mem. Geol. Surv.), 1911. N.B.—It is not proposed to deal fully with this evidence here. The reader is referred to the memoir quoted, pp. 5–56, for abundant details, and to p. 94 for the significant conclusions arrived at by the authors.

[3] See Table of Thicknesses (Table II), p. 403, at end of paper.


RAMSGATE
Eastfleet
Stodmarsh
Wulmestone
WEALDEN
OVERLAP
MAP 2
CANTERBURY
Trapham
Westnesbord
Mutton hill
0 1 2 English 4 Miles 6 8
Chilham
400
Goodnestone
LOWER
GREENSAND
OVERLAP
100
150
300
200
BATHONIAN
DEALX
LIAS
OVERLAP
400
Fredville
250
Tilmanstone
500
Barfreston
Ripple
Ropersole
50
600
Waldershare
Mydlegpole
Guilford
Oxney
OVERLAP
LIAS
100
Brabourne
1000
Ellinge
700
OVERLAP
DOVER
500
Dover
Isopachyte - Systems of the Jurassic
in East Kent
Lias
Oolites
(to top of Portlandian)
Numbers signify thicknesses in feet
By H. A. BAKER, B.Sc., F.G.S.
FOLKESTONE

oolitic limestone with a pebbly base. With regard to the Bathonian, the record of the East Kent borings emphasizes Kendall's remark that "the unconformable overlap of the Great Oolite is one of the most marked features of Oolitic succession in Britain and in the north of France". The overlap of the Bathonian on the Palæozoic floor in East Kent occurs as a zone of N.W.–S.E. trend extending to northward of Stodmarsh and Woodnesborough. In tracing the isopachyte system of the East Kent Oolites the thicknesses[1] have been taken from the base of the Inferior Oolite to the top of the Portlandian, excluding the Purbeckian, since in the boring records the latter is sometimes not separated from the Wealden. Since it is only in the southern part of the area that Oolites higher than Corallian occur, there is no danger of arriving at erroneous conclusions in consequence of the omission of the Purbecks.[2] The Oolite isopachyte system proves very interesting (Map 2, Plate XXVII). We notice again the marked north-easterly thinning of the formation, with a strong tendency on the part of the isopachytes to assume a N.W.–S.E. alignment within the zone of influence of the easterly ridge. We also perceive once more an intimate relationship between the isopachytes and the pre-Upper Cretaceous contours of the Palæozoic floor. The effect of the Deal–Ropersole disturbance upon the isopachytes is very clear. There is, however, a particularly interesting and instructive feature presented by these isopachytes which appears to be missing from those of the Lias. In referring to the general character of the pre-Upper Cretaceous contours of the Palæozoic floor, mention has been made of the abrupt interruption, in the north, of the general north-westerly trend of the contours, and the suggestion has been put forward that this may be due to a movement (late Jurassic or early Cretaceous) of uplift in a new and discordant direction—in fact, roughly east and west. It will be noticed that in the north and west the Oolite isopachytes show a marked tendency to deviate southwards and to approximate to an E.–W. rather than a N.W.–S.E. direction. In the opinion of the present writer this southerly deviation of the Oolite isopachytes may be, in part, the result of denudation consequent upon the appearance of an east and west ridge of Oolitic rocks. It has long been known that such a ridge, extending westward beyond Streatham, existed in late Jurassic or early Cretaceous times, and was subjected to extensive denudation in Lower Greensand times and probably earlier. The writer regards this axis of uplift as one of Armorican affinity. The Oolitic ridge was partially submerged in Lower Greensand times and completely so during Gault times. The deep borings at Bobbing and Richmond showed the Lower Greensand resting on Oolites, while at Stodmarsh, Streatham, and Meux's Brewery the Oolites are directly succeeded by the Gault.

To the north-east of the feather-edge of the Oolites, there is an area, proved by the borings at Walmestone, Mattice Hill, and Ebbsfleet, where the Wealden overlap on the Palæozoic floor occurs. To

[1] See Table II, p. 403, at end of paper.

[2] In point of fact, the inclusion of the Purbecks still further emphasizes the north-easterly thinning of the Oolites.

the south-east of this area there is, in all probability, another where a Lower Greensand overlap occurs, since at Mattice Hill the Wealden is but 2 feet thick. In relation to the alleged easterly Charnian ridge, this area on the Kentish coast immediately to the south-east of the Mattice Hill boring is in parallelism with the boring at Culford in Essex, where the Lower Greensand overlap has been demonstrated. Doubtless, further south-east, beneath the waters of the Straits, there occurs an overlap of the Gault upon the Palæozoic floor in parallelism with the proved overlap at Harwich, Stutton, and Weeley.[1] On the south-easterly extension of the ridge, in North France, there occurs an area where an overlap of the Middle Chalk upon the Palæozoic floor exists. Apparently the ridge attained its greatest elevation to the south-east.

With regard to the isopachyte systems of the Cretaceous members of the Mesozoic cover, it is only to be expected that the intervention of a wedge-like mass of older Mesozoics, and the interference introduced by the Armorican movement, would mask to a large extent the relationship so readily traceable between the isopachytes of these older strata and the contours of the Palæozoic ridge. Nevertheless, in spite of these disturbing elements, it is still possible to perceive the influence of the ancient ridge.

In the opinion of the writer the South-East of England furnishes much evidence suggestive of Charnian posthumous movement, and that afforded by East Kent is a significant contribution.

TABLE I.

Boring.	Base of Gault referred to O.D.	Palæozoic Floor referred to O.D.	Palæozoic Floor when base of Gault is corrected to a datum-plane at O.D.
	Feet.	Feet.	Feet.
Chilham . .	−544	−1,022	− 478
Brabourne .	+149	−1,706	−1,855
Stodmarsh .	−931	− 979	− 48
Trapham .	−841	−1,065	− 224
Goodnestone .	−825	−1,052	− 227
Woodnesborough	−917	−1,021	− 104
Fredville . .	−689	−1,109	− 420
Barfreston .	−691	−1,027	− 336
Tilmanstone .	−711	− 943	− 232
Maydensole .	−641[2] (?)	− 941	− 300[2] (?)
Ripple . .	−722	− 814	− 92
Oxney . .	−696	− 859	− 163
Ropersole .	−553	−1,174	− 621
Waldershare .	−651	−1,069	− 418
Ellinge . .	−273	−1,211	− 938
Dover . .	−192	−1,108	− 916
Ebbsfleet . .	−995	−1,046	− 51
Mattice Hill .	−909	− 964	− 55
Walmestone .	−978	−1,001	− 23

[1] The Gault overlap has been proved in a deep boring at Calais.
[2] Estimated.

TABLE II.

Boring.	Thickness of Lias if present.	Thickness of Oolites, excluding Purbeck, if present.
		Feet.
Chilham . .	23½ feet	412¾
Brabourne . .	140 ,,	1,020
Stodmarsh . .	? 5 ,,	43
Trapham . .	Absent	126
Goodnestone .	Absent	142
Woodnesborough	Absent	30
Fredville . .	10½ feet	323
Barfreston . .	Absent	257
Tilmanstone .	Absent	133
Maydensole .	Absent	152
Ripple . .	Absent	? (less than 92)
Oxney . .	Absent	93
Ropersole . .	21½ feet	463
Waldershare .	5 ,,	301
Ellinge . .	54 ,,	695
Dover . .	38 ,,	504
Ebbsfleet . .	Absent	Absent
Mattice Hill .	Absent	Absent
Walmestone .	Absent	Absent

IV.—Albite-Granophyre and Quartz-Porphyry from Brandy Gill, Carrock Fell.

By Arthur Holmes, A.R.C.S., D.Sc., F.G.S.

With an analysis by H. F. Harwood, M.Sc., Ph.D.

Introduction.

In the course of an investigation into British resources of sands and rocks for glass-making and refractory purposes, which is being carried out by my colleague Dr. P. G. H. Boswell, it became desirable to search for an alumina-bearing siliceous rock low in iron-content. Among other rocks considered by Dr. Boswell was the granophyre of Brandy Gill, and a sample, obtained from Mr. W. Hemingway, was submitted to Dr. H. F. Harwood for analysis. So far as industry is concerned, the analysis indicates that the iron-percentage of the rock is too high for its use in glass manufacture. As such an analysis would be of interest and value to geologists—there being few first-class analyses of Lake District igneous rocks—and as it seemed undesirable that only a bare record should occur in a technological publication, Dr. Boswell handed to me the analysis and a sample of the granophyre, with the suggestion that the rock might be described in the pages of the Geological Magazine.

I am indebted to Mr. Hemingway for two additional specimens of the rock, which occurs near the head of Brandy Gill, west of Carrock Fell. These specimens, though from practically the same locality as the granophyre, differ from it in having somewhat larger phenocrysts of quartz and albite and a more finely grained ground-mass very nearly free from micrographic texture. They are

therefore more accurately described as albite quartz-porphyry. Mr. Hemingway states that the rock was first noted in some mine workings near the head of Brandy Gill, where it was covered at the surface by a white decomposition product. The latter, which is known as "the china-clay bed" has been traced for more than a mile in a westerly direction. At Arye-stones the deposit is very extensive, but the fresh rock below was cut through by the old levels of the Roughten Gill lead-mines. At Brandy Gill the rock is penetrated by the tungsten veins of the Carrock mines, which carry scheelite and wulfenite.[1]

Petrography of the Albite Granophyre.

The granophyre of the Carrock Fell complex and its variations are well known from the description by Dr. Harker.[2] He describes the normal granophyre as showing[3] "small scattered crystals of black augite [diopside approaching hedenbergite] and white or glassy-looking oligoclase, in a fine-textured grey or cream-coloured or reddish groundmass". He then continues, "In some of the more acid examples the augite is wholly or almost wholly absent, and the rock has a white colour. This is the case at the head of Brandy Gill and in the peat moss south of Drygill Head, and the specific gravity of these specimens is naturally very low (2·578 and 2·530)."

The specimen analysed by Dr. Harwood is a white quartzite-like rock with sparsely distributed rectangular crystals of felspar which average about 3 mm. by 1 mm. in areal dimensions. The specific gravity is 2·63.

Under the microscope the felspar phenocrysts are seen to be dusky from incipient alteration, and to carry as inclusions small films and fans of muscovite. Albite, pericline, and carlsbad types of twinning are developed. A few cleavage flakes were obtained by crushing the rock, and the extinction angles (up to 19° on 010), mean refractive index (between 1·53, chlorobenzene, and 1·54, clove oil), and specific gravity (2·63 in a Klein solution of that density) indicate that the felspar is albite, a conclusion which is verified by the analysis.

The rock is crowded with small irregular crystals of quartz, often corroded, and varying regularly in size from undoubted phenocrysts to small masses that form part of the micrographic groundmass. The latter is of the finely textured type described by Harker,[4] with occasional felspar nuclei in optical continuity with that of the surrounding intergrowth. There are, however, numerous minute wisps of muscovite in the groundmass, and much of the felspar of the latter is altered to cloudy aggregates of sericite. Moreover, the rock contains here and there small fans of radiating muscovite with which zircon in well-crystallized prisms or rounded grains is invariably associated. No definite pyroxene has been

[1] For an account of similar veins in the Grainsgill greisen see A. M. Finlayson, Geol. Mag., Dec. V, Vol. VII, p. 19, 1910.

[2] "The Carrock Fell Granophyre": Q.J.G.S., li, p. 125, 1895 (Map of the Carrock Fell District, plate iv).

[3] Ibid., p. 131.

[4] Loc. cit., p. 128.

detected, but there are a few vague dark-green to black chloritic alteration products that may represent traces of a mafic mineral.

Sections show the presence of two kinds of microscopic veins, both being exceedingly thin and dying out within the limits of the section. The first of these consists of a quartz mosaic containing tiny specks of muscovite that twinkle like calcite over a rotating nicol. The second type of vein consists of dolomite and calcite, and is, as far as the evidence goes, later than the quartz type. The rock contains sufficient carbonate to effervesce with cold dilute acid when powdered. The analysis indicated that not all the carbonate could be calcite, and to test this point an uncovered section was prepared and treated with Lemberg's (logwood) solution. The greater part of the carbonate mineral failed to take the stain, thus confirming the presence of dolomite deduced from the analysis.

The chief accessory mineral seen in thin section in addition to those already mentioned is pyrite, though only two or three small cubic cross-sections have been seen in several slides. However, accessory minerals were also sought by the method adopted in the investigation of other Lake District granitic works by Messrs. Rastall and Wilcockson.[1] Some of the rock was crushed and a separation of the heavier particles was effected straight away with a Thoulet solution (potassium mercury iodide) having a specific gravity of about 3. A preliminary separation by panning was avoided because of shortage of material, and because of the paucity of heavy minerals, most of which would have been washed away by such a process. As soon as the crushed rock was stirred into the solution a few black grains could be seen falling through the white felsic constituents, and after a few minutes sufficient material was drawn off for examination. The magnetic portion, which was about a third of the whole, contained pyrrhotite with a little magnetite. This result is interesting in view of the universal occurrence of pyrrhotite in the other Lake District granitic rocks.[2] The residue (not picked up by a bar-magnet) consisted, in order of abundance, of pyrite, ilmenite, and zircon.

Chemical Analysis.

In calculating the mineral composition as given below, I have departed from the conventions of the *norm*. The norm would have shown figures for orthoclase and corundum. Corundum is certainly not present and orthoclase has not been detected, its place being taken by muscovite and sericite. For this reason the potash was expressed mineralogically as muscovite and the remaining alumina calculated as kaolin. As there is insufficient lime to satisfy all the carbon dioxide (and therefore none available for felspar) it was necessary to use some of the magnesia for this purpose, a procedure justified by the actual presence of dolomite in the rock. "Hypersthene" is probably the partial representation of the chloritic alteration products mentioned below.

[1] Q.J.G.S., lxxi, p. 592, 1915.
[2] Ibid., p. 617.

The following analysis of the Brandy Gill granophyre was made by Dr. H. F. Harwood:—

Percentages.		*Molecular Proportions.*	*Mineral Composition.*	
SiO_2	80·12	1·3353	Quartz	53·57
Al_2O_3	10·68	·1047	Albite	29·08
Fe_2O_3	0·06	·0004	Muscovite	12·12
FeO	0·49	·0068	Kaolin	1·00
MgO	0·63	·0157		
CaO	1·01	·0180	Hypersthene	1·23
Na_2O	3·44	·0555		
K_2O	1·42	·0151	Magnetite	0·09
H_2O+	0·80	·0444	Ilmenite	0·16
H_2O-	0·28	—	Pyrite	0·17
CO_2	1·20	·0273		
TiO_2	0·09	·0011	Zircon	0·04
P_2O_5	trace	—		
MnO	0·05	·0007	Dolomite	1·66
S	0·09	·0028	Calcite	0·90
BaO	0·01	—		
ZrO_2	0·03	·0002	Water	0·40
	100·40			100·42
Less O for S	0·03		Less O for S	0·03
Total	100·37		Total	100·39

The analysis is remarkable for the high percentage of silica that it reveals. The highest percentage found in the estimations made for Dr. Harker was 77·38, while in the specimen analysed by Mr. Barrow the silica amounted to 71·60 per cent.[1] The high alumina relative to alkalies has been interpreted above. The abundance of soda compared with potash justifies the name, *albite-granophyre*, applied to the rock.

Albite-Quartz-Porphyry.

The distinguishing features of this rock have already been stated above. The specimens are from one of those portions of the "granophyre" which "show little or no graphic structure at all, the quartz and felspar forming an irregular mosaic. In this case the quartz tends to occur partly in larger crystal-grains, and the rock approximates to some quartz-porphyries". To this description[2] there is little to add. The felspar is again albite, and quartz, which is very abundant, corrodes the felspar and is itself corroded by the groundmass. Muscovite occurs in larger wisps than in the granophyre, and also forms curious vermicular aggregates in the groundmass. As in the granophyre the rock contains narrow veins of quartz, and smaller ones containing carbonate minerals. The remaining minerals were determined by separation with Thoulet solution, using much more material than was available of the granophyre. The crop of heavy minerals proved to be identical with that obtained from the latter, except that in the residue remaining

[1] A. Harker, loc. cit., pp. 129–30.
[2] Harker, loc. cit., p. 128.

after treatment with a bar-magnet, a grain or two of brown tourmaline was also found. The specific gravity of both specimens is 2·63, the same figure as that for the granophyre.

Mr. Hemingway states that the rock is very similar to the white felsite interbedded in the Drygill shales to the north of Brandy Gill.

Geological Age.

It may be of interest to draw attention here to the recent work of Mr. J. F. N. Green on the age of the Carrock Fell complex.[1] It is well known that the complex is of later date than the Borrowdale volcanic series. An upper limit is fixed by Mr. Green's discovery of granophyre fragments in the Watch Hill Beds. These consist of shales and polygenetic grits which form a series of patches lying at various horizons on the Skiddaw Slates between Cockermouth (Watch Hill) and Great Sca Fell.[2] Only one pebble of granophyre was found at Watch Hill, but in the eastern exposures (i.e. in those near to Carrock Fell) the rock was found to be invariably present in the coarser bands of the series. Mr. Green shows that the Watch Hill Beds are younger than the Borrowdale Series and older than the Devonian earth-movements, and for these and other reasons he correlates them with the Coniston Limestone Series. Consequently he considers the igneous rocks of Carrock Fell to be pre-Bala. Mr. Green concludes: "The Borrowdale Series is ascribed to the Middle Llanvirn . . . The Eskdale granite, Buttermere granophyre, St. John's granite-porphyry, and Carrick Fell complex all belong to the suite, being intruded before the solfataric stage, but at a late period of the episode."

V.—The Fossils of the East Anglian Sub-Crag Boxstones.

By Alfred Bell.

IN the opening article of the Geological Magazine (Vol. I, p. 5, 1864) Mr. J. W. Salter remarks: "An obscure but novel group of organic remains comes to light in some well-worked district for which we have as yet no fixed geological place," and this description may well apply to the fauna dealt with in the following pages.

Usually considered by geological writers as being derived from sources outside the East Anglian area, very little attention has been paid to it, its environment, or to its Continental affinities. The fossils hereafter referred to occur in a sandstone matrix[3] more or less consolidated, the relics of a former stratum afterwards broken up, and now found distributed in places beneath the overlying Pliocene deposits, between Walton-on-the-Naze and Hollesley on the coast and inland to about Ipswich.

[1] "The Age of the Chief Intrusions of the Lake District": Proc. Geol. Assoc., xxviii, pp. 17–25, 1917.

[2] Ibid., plate ii.

[3] An interesting and important paper dealing with the petrology of the Suffolk "Boxstones" (Crag), by Dr. P. G. H. Boswell, D.I.C., F.G.S. (now Professor of Geology in the University of Liverpool), appeared in the Geological Magazine for June, 1915 (pp. 250–9, Plate X, and Figs. 1–3) and may be consulted with advantage by readers of the present paper.

Within these boundaries the bed-rock is a floor of London Clay, formerly covered by a higher zone of the same material, replete with a fauna of similar type to that found at Sheppey, including fishes and Crustaceans in fine preservation, the broken-up clay and the fossils being deeply phosphatized. Upon this, again, there seems to have been deposited a bed of sand of which the actual presence can only be inferred, since it has not been found in situ as a separate stratigraphical unit or stratum; but the suggestion is warranted by the mass of debris yielding a particular group of fossils found in the irregular blocks of indurated sandstone or loosely distributed in the adjacent Crag sands, and in the tabular pieces present at Trimley, Bucklesham, and other places, of which Dr. J. E. Taylor writes in White's *History of Suffolk*, 1874, "that it is not uncommon to find slabs of the same kind of sandstone which appear to have undergone little abrasion and to be in nearly the same condition they were in when the formation to which they originally belonged was broken up." Similar pieces of sandstone with sharply defined impressions of the fossils and shells, more or less unworn, may be obtained occasionally during low tides at Bawdsey, where a bed of the nodules may be seen at times near the Haven.

The petrology of the "boxstones" has been fully described by Dr. Boswell, F.G.S.,[1] and the general features of the detritus by myself.[2]

In the discussion following the reading of Professor Lankester's paper[3] "On the Newer Tertiaries of Suffolk and their Fauna", Sir C. Lyell pronounced the boxstones then produced as being similar to those he had seen at Berchem, near Antwerp, in 1851,[4] in a deposit of Rupelien age, the shells corresponding to those figured by de Koninck in his well-known memoir[5] on the fossil shells of Basele, Boom, etc.

This particular horizon has been referred by M. van den Broeck[6] to the uppermost stage of the Middle Oligocene; a system largely developed, according to von Koenen, Ravn, and other writers, in Denmark, Belgium, and North-West Germany; with a few exceptions the boxstone species agree with those found in one or other of these localities.

The English literature bearing upon the deposit and the faunas associated with it before 1865 is very scanty. Charlesworth, in 1837, figured a tooth of *Carcharias megalodon*, with sundry notes on the phosphatic nodules; and the so-called "Coprolites" and mammalia recorded between then and 1851 are mentioned in the bibliography appended to C. Reid's *Pliocene Deposits of Great Britain* (1890). The earliest descriptive account[7] is that given by the Rev. W. B.

[1] "Petrology of the Suffolk Boxstones": op. cit.
[2] "Sub-Crag Detritus": Proc. Prehistoric Soc. East Anglia, 1915, vol. xi, pp. 139–48.
[3] Quart. Journ. Geol. Soc., vol. xxvi, pp. 493–513, 1870.
[4] Quart. Journ. Geol. Soc., vol. viii, p. 282, 1852.
[5] Mém. Acad. R. Sci. Bruxelles, vol. xi, 1837.
[6] Bull. Soc. Belge Géol., vol. vii, p. 299, 1893.
[7] Ann. Nat. Hist. (2), vol. viii, pp. 206–11, 1851.

Clarke, of Ipswich, on the nodule "bed" and its contents, figuring amongst other items a ziphioid rostrum. This was apparently reproduced with other species in an early paper on Red Crag Mammals,[1] by Professor Owen.

Mr. S. V. Wood was the first to recognize the shells in the boxstones,[2] specifying several of these by name, but nothing further was done till Professor Sir Ray Lankester, in 1865, briefly noticed the deposit and, in 1868,[3] discussed at some length its possible origin and that of its contents.

Unfortunately for science, the closing of the "Coprolite" industry or phosphate diggings, and the little interest taken in the stones when they were obtainable, limits the scope of our inquiry, and all that can be done is to utilize the material at hand. This is chiefly conserved in the Museums of Practical Geology, London, Ipswich, Norwich, and York, and in one or two private collections, all of which, by the courtesy of those in charge of them, it has been my privilege critically to examine. I have also to thank the Trustees of the Percy Sladen Memorial Fund for assistance in collecting information.

The specimens upon which the following lists are founded commonly occur as moulds of the exterior of the shells, showing the sculpture, or as casts of the interior; the shelly matter being rarely preserved. From these it has been possible by the use of wax or gutta-percha to reproduce the general details of the organism, which has been done by permission, from a number of the rarer and more perfect examples, especially those in the York and Norwich Museums. These will be ultimately added to those specimens already preserved in the Museum of Practical Geology, London.

The fossils are so scattered that it may be useful to students to know the Museums where they can be seen, and to have a reference to some good figure of the shell referred to in the text. As a rule the organisms have suffered little attrition, the sculptural details are well preserved, and most of the bivalves are found closed, as if embedded alive before the muscles had become relaxed.

Boxstone Mollusca.

Cylichna sp.

Cylichna cylindracea, Ravn, K. Danske Vid. Selsk. Skrift. (7), vol. iii, p. 367, pl. viii, fig. 15, 1907. Mus. Pract. Geol. London, York.

Ringicula auriculata, Menard.

Ringicula auriculata. Beyrich, Zeitsch. deutsch. Geol. Ges., vol. v, p. 330, pl. v, fig. 13, 1853. Mus. Pract. Geol. London.

Ringicula striata, Philippi.

Ringicula striata, Philippi, Beit. tert. N.W. Deutschl., p. 28, pl. iv, fig. 23, 1843.
,, ,, Ravn, K. Danske Vid. Selsk. Skrift. (7), vol. iii, p. 365, pl. viii, fig. 11, 1907.
Mus. Pract. Geol. London.

[1] Quart. Journ. Geol. Soc., vol. xii, 1856.
[2] Crag Moll., pt. ii, 1851.
[3] Geol. Mag., Vol. II, pp. 103–49, 1865; Vol. V, p. 254, 1868.

Conus Dujardini, Deshayes.

Conus Dujardini, Hörnes, Foss. Moll. Tert. Wien, vol. i, p. 40, pl. v, figs. 3–8, 1856.

,, ,, Lankester, Quart. Journ. Geol. Soc., vol. xxvi, p. 502, pl. xxxiv, fig. 5, 1870.

Mus. Ipswich, Norwich.

Conus antediluvianus, var. B, Grateloup.

Conus antediluvianus, var. B, Grateloup, Atlas Conch. foss. de l'Adour, No. 44, fig. 6, 1840. Mus. Ipswich, York.

Conus cf. *ventricosus*, Bronn.

Conus ventricosus, Hörnes, Foss. Moll. Tert. Wien, vol. i, p. 32, pl. iii, figs. 5–6, 1856.

,, ,, Fontannes, Moll. plioc. Vall. du Rhone, vol. i, p. 144, pl. viii, fig. 11, 1887.

Mus. Ipswich.

Pseudotoma Morreni, de Koninck.

Pleurotoma Morreni (de Koninck), Coq. foss. Basele, 1837, p. 21, pl. i, fig. 3. Mus. Ipswich.

[Mr. F. W. Harmer (Plioc. Moll. Gt. Brit., pt. ii, p. 212, regards this shell as a variety of *Pl. intorta*, Brocchi, with which it has many points of resemblance.]

Pleurotoma Steinvorthi, Semper.

Pleurotoma Steinvorthi, von Koenen, Mioc. nord-Deutschl., p. 94, pl. ii, fig. 10, 1872.

,, ,, Norregaard, Dansk. Geol. Foren., vol. v, p. 133, pl. iii, fig. 10, 1916.

Cancellaria (*Trigonostoma*) cf. *ampullacea* (Brocchi).

Voluta ampullacea, Brocchi, Conch. foss. Sub-ap., vol. ii, p. 313, pl. iii, fig. 9.

Trigonostoma ampullacea, Sacco, Moll. Tert. terz. Piem., pt. xvi, p. 9, pl. i, figs. 16–20.

[Some imperfect forms at Ipswich may belong to *C. umbilicaris*, Brocchi, but as the aperture is not seen in either species, both ascriptions may need revision.]

Cancellaria (*Ventrilia*) *aperta* (Beyrich).

Cancellaria aperta, Beyrich, Zeitsch. deutsch. Geol. Ges., vol. viii, p. 586, pl. xix, fig. 5, 1856. Mus. York.

Ancilla Nysti, F. W. Harmer.

Ancilla Nysti, F. W. Harmer, Plioc. Moll. Gt. Brit., pt. i, p. 52, pl. xii, figs. 32–3, 1913. Harmer Coll.

Voluta (*Pyrgomitra*) *fusus* (Philippi).

Fasciolaria fusus, Philippi, Beit. N.W. deutsch. tert., p. 25, pl. iv, fig. 14, 1843.

Voluta parca, Beyrich, Zeitsch. deutsch. Geol. Ges., vol. v, p. 357, pl. viii, fig. 1, 1853. Mus. York, Ipswich.

[These figures represent the younger and older states of the shell. It has a longer and narrower canal than the typical *V. Lamberti* of the Anglo-Belgian Crag basin. Dr. Mörch, in the Journ. de Conch., vol. xvii, p. 428, 1869, assigns this group to the sub-genus *Pyrgomitra*.]

Voluta (*Pyrgomitra*) sp.

Voluta cf. *tarbelliana*, var. *ventricosa*, Grateloup, Atlas Conch. foss. l'Adour, pl. xxxix, fig. 2, 1840.

Voluta auris-leporis, Lankester, Quart. Journ. Geol. Soc., vol. xxvi, p. 502, pl. xxxiv, fig. 6, 1870.

Mus. Ipswich.

Mitra cf. *fusiformis*, Brocchi.

Mitra fusiformis, Cerulli-Irelli, Pal. ital., vol. xvii, p. 235, pl. xxi, fig. 19, 1911. Mus. Pract. Geol., London.

[The reference is founded on the cast of a long body and next whorl, 60 mm. long, 25 mm. broad, with a nearly straight figure. *Mitra Venayssina*, Fontannes, Moll. Plioc. Vall. du Rhone, vol. i, p. 79, pl. vi, fig. 1, is closely allied to it.]

Sipho gregarius (Philippi), *pars.*

Fusus gregarius, Beyrich, Zeitsch. deutsch. Geol. Ges., vol. viii, p. 59, pl. v, figs. 7–8, 1856. Mus. Norwich, Ipswich.

Sipho lineatus (de Koninck).

Fusus lineatus, de Koninck, Coq. foss. Basele, p. 18, pl. iii, figs. 1, 2, 1837. Mus. Pract. Geol. London, Ipswich, York.

Sipho multisulcatus (Nyst).

Fusus multisulcatus, Nyst, Coq. foss. Belge, p. 494, pl. xl, fig. 1, 1843. Mus. Pract. Geol. London.

[Nyst altered de Koninck's specific name *lineatus* to *multisulcatus*, but his figure is not the same as de Koninck's, which shows a shell having a longer spire and canal, and narrower in proportion. They may be varieties of a polymorphous form, but as both varieties occur in the boxstones they are given accordingly for what they are worth.]

Sipho major, A. Bell.

Sipho major, A. Bell, Journ. Ipswich Field Club, vol. iii, p. 9, 1911.
Fusus erraticus, var., Harder, Danm. Geol. Undersøg., vol. ii, p. 83, pl. vi, fig. 31, 1913.

Mus. Ipswich.

[This is a large shell, the three lower whorls measuring 80 mm. in length with a breadth of 35 mm. This and the next species may perhaps represent a new group, intermediate between *Sipho* and *Fasciolaria*, as the moulds of the upper whorls show traces of costal ornament. Of this group *Fusus* (aff.) *Koninckı*, Ravn, K. Danske Vid. Selsk. Skrift (7), vol. iii, pl. v, fig. 10, might be taken as the type.]

Sipho Ravni, sp. nov.

Fusus erraticus, var., Ravn, K. Danske Vid. Selsk. Skrift (7), vol. iii, p. 333, pl. vi, fig. 13, 1907. Mus. Pract. Geol. London, Norwich.

Fasciolaria (*Surculofusus*) *erraticus* (de Koninck).

Fusus erraticus, de Koninck, Coq. foss. Basele, p. 19, pl. ii, fig. 5, 1837.
,, ,, Nyst, Coq. foss. Belge, p. 496, pl. xl, fig. 2, 1843.

Mus. Pract. Geol. London, Ipswich.

Liomesus nudum (S. V. Wood).

Buccinum nudum, S. V. Wood, Mon. Crag Moll., Suppl. 2, p. 1, pl. i, fig. 1, 1879.

Liomesus ventrosus (Beyrich).

Fusus ventrosus, Beyrich, Zeitsch. deutsch. Geol. Ges., vol. viii, p. 35, pl. ii, figs. 3–5, 1856.
Buccinopsis Dalei, Ravn, K. Danske Vid. Selsk. Skrift (7), vol. iii, p. 313, pl. v, fig. 1, 1907.

Moore and Stanley Coll.

[Many of the shells found in the Scaldisien beds in Belgium figured as *B. Dalei*, Sow., are much nearer to this species than to those in the English Crag. Fig. 4 in Beyrich's plate is an almost exact delineation of some of the Belgian forms.]

Liomesus cf. *danicus* (von Koenen).

Buccinopsis danicus, Ravn, K. Danske Vid. Selsk. Skrift (7), vol. iii, p. 313, pl. iv, figs. 10–11, 1886. Mus. Pract. Geol., London.

[The shells figured by Ravn are both imperfect, and the London specimen is referred to it with some doubt as only the dorsal aspect is exposed. It is a rare shell on the Continent, as it is only recorded from the Danish Oligocenes.]

Cominella conica, sp. nov.

A smooth elongate bucciniform shell, channelled at the upper part of the volutions. Whorls 5–6, rounded and sub-carinated. Apex blunt. Aperture semilunate. Outer lip thickened, base but slightly prolonged. Umbilicus exposed by the loss of shelly matter. Height 35 mm., breadth 20 mm. Mus. Ipswich, Cambridge.

Desmoulea conglobata (Brocchi).

Buccinum conglobatum, Brocchi, Conch. foss. Subap., vol. i, p. 334, pl. iv, fig. 15, 1814.

Nassa conglobata, S. V. Wood, Mon. Crag Moll., pt. i, p. 32, pl. iii, fig. 9, 1848.

Mus. Pract. Geol. London, York, Ipswich.

Semicassis saburon (Bruguière).

Cassis saburon, Beyrich, Zeitsch. deutsch. Geol. Ges., vol. vi, p. 480, pl. xii, fig. 5, 1854.

Cassidaria sp., Lankester, Quart. Journ. Geol. Soc., vol. xxvi, p. 502, pl. xxxiv, fig. 8, 1870.

In most collections.

Echinophoria sulcosa (Lamarck).

Cassis sulcosa, Hörnes, Foss. Moll. Tert. Wien, vol. i, p. 179, pl. xv, fig. 8, 1856.

Cassidaria sp., Lankester, Quart. Journ. Geol. Soc., vol. xxvi, p. 502, pl. xxxiv, fig. 9, 1870.

Mus. Pract. Geol. London, Ipswich.

Echinophoria Rondeleti (Basterot).

Cassis Rondeleti, Basterot, Mém. Géol. sur les Env. de Bordeaux, p. 51, pl. iii, fig. 22; pl. iv, fig. 13, 1825.

Cassis Rondeleti, Ravn, K. Danske Vid. Selsk. Skrift (7), vol. iii, p. 307, pl. iv, fig. 9, 1907.

Mus. Ipswich.

[The late Mr. C. Reid includes *Cassidaria bicatenata* in his list of Mollusca from the Suffolk boxstones. Plioc. Dep. of Britain, p. 13. It is probably a clerical error.]

Ficula acclinis (S. V. Wood).

Pyrula acclinis, S. V. Wood, Mon. Crag Moll., pt. ii, p. 311, pl. xxxi, fig. 6, 1850. In most collections.

[The most characteristic feature of this species is the great breadth of the upper part of the whorls. *Pyrula condita* in Hörnes' great work, vol. i, pl. xxviii, fig. 4, seems to agree with Wood's shell.]

Ficula cingulata (Bronn).

Pyrula cingulata, Hörnes, Foss. Moll. Tert. Wien, vol. i, p. 676, pl. xxviii, fig. 1, 1856 (figured as *P. reticulata*). Mus. Pract. Geol. London, York, Ipswich.

Ficula condita (Brongniart).

Pyrula condita, Brongniart, Mém. sur les Terr. du Vicentin, p. 75, pl. vi, fig. 4, 1823.

Pyrula reticulata, S. V. Wood, Mon. Crag Moll., pt. i, p. 42, pl. ii, fig. 12, 1848.

Mus. Pract. Geol. London, York, Ipswich.

Ficula cf. *geometra* (Borson).

Pyrula geometra, Hörnes, Foss. Moll. Tert. Wien, vol. i, p. 271, pl. xxviii, fig. 7, 8, 1856. Mus. Pract. Geol. London.

[A graceful cast in this museum may be assigned to this species with some uncertainty. In form and outline, however, it corresponds to Hörnes' and Sacco's figures of the shell.]

Pseudocassis sphærica (Philippi).

Cypræa spherica, Beyrich, Zeitsch. deutsch. geol. Ges., vol. v, p. 319, pl. iv, fig. 9, 1853. Mus. York.

[Mr. F. W. Harmer has in his collection a cast of a shell belonging to this group, having the inner whorls coiled on a flat plane round the apex as in some of the Conidæ, height 30 mm., breadth 20 mm., found at Waldringfield. For the genus see Fischer, Manuel de Conchyliologie, p. 668.]

Trivia pisolina (Lamarck).

Cypræa pisolina, Lamarck (Deshayes), Anim. sans Vertebr., 2nd ed., vol. vii, p. 408, 1822.

Trivia pisolina, F. W. Harmer, Plioc. Moll. Gt. Brit., pt. i, p. 50, pl. ii, fig. 17, 1913.

Moore Coll.

Rimella gracilenta (S. V. Wood).

Rostellaria (?) *gracilenta*, S. V. Wood, Mon. Crag Moll., Suppl. 3, p. 1, pl. i, fig. 1, 1882. Mus. Ipswich.

Rimella lucida (?), (S. V. Wood), J. Sowerby.

Rostellaria lucida (?), S. V. Wood, Mon. Crag Moll., Suppl. 1, pt. i, p. 5, pl. ii, fig. 14, 1872. Mus. Ipswich.

Rostellaria dentata, Grateloup.

Rostellaria dentata, Grateloup, Atlas Conch. foss. de l'Adour, No. 32, fig. 4, 1840.

,, ,, Cossmann, Ess. Paléoconch. compar., vol. vi, p. 19, pl. ii, fig. 12, 13, 1904.

Mus. Ipswich.

Hippochrenes ampla Rutoti, var. nov.

Rostellaria ampla, Rutot, Ann. Soc. malac. Belge, vol. xi, p. 33, pls. i, ii, 1874. Mus. Norwich (spire), Ipswich (body).

Aporrhais speciosus (Schlotheim).

Aporrhais speciosus, Beyrich, Zeitsch. deutsch. geol. Ges., vol. vi, p. 492, pl. xiv, figs. 1–3, 1854.

,, ,, Ravn, K. Danske Vid. Selsk. Skrift (7), vol. iii, p. 302, pl. iii, fig. 24, 1907.

Mus. Ipswich.

Cerithium acuticosta angulatior, Sacco.

Cerithium acuticosta, var. *angulatior*, Sacco, Moll. Terr. terz. Piemonte, pt. xvii, p. 4, pl. i, fig. 6, 1895. Mus. Norwich.

Vermetus (*Burtinella*) *Bognoriensis*, Mantell.

Vermetus Bognoriensis (?), S. V. Wood, Mon. Crag Moll., pt. i, p. 114, pl. xii, fig. 9, 1848. Mus. Ipswich.

[This shell (or annelid) is commonly diffused in the loose sands of the older Red Crags, as well as in the hardened original matrix. S. V. Wood, Suppl. 3, p. 1.]

Vermilia flagelliformis (Morris).

Serpula flagelliformis, J. Sowerby, Min. Conch., vol. vii, p. 50, pl. dcxxxiv, figs. 2, 3, 1844. Attached to shell of *Pectunculus*. Mus. York.

Turritella Geinitzi, Speyer.

Turritella Geinitzi, Speyer, Palæontographica, vol. xvi, p. 22, pl. ii, fig. 2, 1866.
,, ,, Norregaard, Danske Geol. Forening, vol. v, p. 122, pl. iii, fig. 7, 1916.
Mus. Ipswich.

Xenophora Deshayesi (Michelotti).

Xenophora Deshayesi, Hörnes, Foss. Moll. Tert. Wien, vol. i, p. 442, pl. xliv, fig. 12, 1856.
,, ,, Sacco, Moll. Terr. terz. Piemonte, pt. xx, pl. ii, fig. 20, 1896.
Mus. Pract. Geol. London.

Xenophora scrutaria (Philippi).

Trochus scrutaria, Philippi, Beit. Tert. N.W. Deutschlands, p. 22, pl. iii, fig. 37, 1843.
Xenophoria scrutaria, Speyer, Palæontographica, vol. xvi, p. 328, pl. xxxiv, fig. 8, 1866.
Mus. Pract. Geol. London.

Natica achatensis (Recluz MS.), de Koninck.

Natica achatensis, de Koninck, Coq. foss. Basele, p. 9, 1837.
Natica glaucinoides, Nyst, Coq. foss. Belge, p. 442, pl. xxxvii, fig. 32, 1843.
Mus. Pract. Geol. London, York, Ipswich.

Natica Nysti, cf. D'Orbigny.

Natica Nysti, Ravn, K. Danske Vid. Selsk. Skrift (7), vol. iii, p. 293, pl. iii, fig. 10, 1907. In most collections.

Natica cf. *hantoniensis*, Pilkington.

Natica hantoniensis, von Koenen, Palæontographica, vol. xvi, p. 148, pl. xii, fig. 9, 1867.
,, ,, Ravn, K. Danske Vid. Selsk. Skrift (7), vol. iii, p. 290, pl. iii, fig. 6, 1907.
Mus. York.

[This fine cast, height 33 mm., breadth 25 mm., is clean from any adventitious matter. Its globose form and straightness of columella indicate its connection with the above species. Unfortunately the outer mould was not preserved.]

Natica (*Crommium*) *ferruginea italica* (Sacco).

Crommium ferrugineum italica, Sacco, Moll. Terr. terz. Piemonte, pt. ix, p. 8, pl. i, fig. 8, 1891. Mus. Pract. Geol. London, Ipswich.

Natica elongata, Michelotti.

Natica elongata, Michelotti, Et. Mioc. Inf. d'Italie, p. 88, pl. x, fig. 34, 1861.
Euspirocrommium elongatum, Sacco, Moll. Terr. terz. Piemonte, pt. ix, p. 10, pl. i, fig. 11, 1891.
Stanley Coll.

Niso sp.

[The cast referred to this genus exhibits the perforated axis very clearly, and is probably that of one of the many forms of *Niso* (*Bonellia*) *terebellata*, Grateloup, figured by Sacco, Moll. Terr. terz. Piemonte, pt. xi, pl. i, figs. 39–52. Harmer Coll.]

Bolma granosa miocenica, Sacco.

Bolma granosa miocenica, Sacco, Moll. Terr. terz. Piemonte, pt. xxi, p. 13, pl. i, fig. 28, 1896. Mus. Pract. Geol. London.

Phorcus striatus, Risso.

Phorcus striatus, Risso, Hist. Nat. Eur. merid., vol. iv, p. 134, 1826.

[Risso's diagnosis of this species, which he only knew as fossil, equally describes the boxstone shell, so as to render them practically identical. Mus. Ipswich.]

Calliostoma millegranus præcedens (von Koenen).

Trochus labarum (?), Basterot, Mém. Géol. de l'Env. de Bordeaux, 1825, p. 33, pl. i, fig. 23.

Trochus miliaris, Hörnes, Foss. Moll. Tert. Wien, vol. i, p. 454, pl. xlv, fig. 9, 1856.

Trochus millegranus præcedens, von Koenen, Mioc. N. Deutschlands (Marburg), p. 308, 1872.

Mus. Pract. Geol. London.

Calliostoma Xavieri (Costa MS.).

Trochus Xavieri, Dollfus, Cotter, & Gomes, Moll. tert. du Portugal, p. 6, pl. xxxi, fig. 4, 1903.

Zizyphinus opisthosthenus, cf. Fontannes, Moll. Plioc. de la Vall. du Rhone, vol. i, p. 218, p. xi, fig. 22, 1897.

Mus. Ipswich.

Dentalium sp.

(?) *Dentalium fossile*, Hörnes, Foss. Moll. Tert. Wien, vol. i, p. 657, pl. i, fig. 36, 1856. Stanley Coll.

Dentalium Kickxii, Nyst.

Dentalium Kickxii, Nyst, Coq. foss. Belge, p. 342, pl. xxxvi, fig. 1, 1843.

,, ,, Ravn, K. Danske Vid. Selsk. Skrift (7), vol. iii, p. 286, pl. iii, fig. 4, 1907.

Mus. Pract. Geol. London.

Spondylus sp.

[The genus is represented by a perfect upper valve with the inner side exposed showing the characteristic dentition. It is recorded from the Belgian Oligocenes. See Vincent, Ann. Soc. malac. de Belge, vol. xxiii, 1888. Mus. York.]

Pecten (*Chlamys*) *Malvinæ*, Dubois de Montperoux.

Pecten Malvinæ, Dubois de Montperoux, Coq. foss. Wolhyma, p. 71, pl. viii, figs. 2–3, 1831.

,, ,, Hörnes, Foss. Moll. Tert. Wien, vol. ii, p. 414, pl. lxiv, fig. 5, 1870.

Stanley Coll.

Pecten (*Chlamys*) *Sollingensis*, von Koenen.

Pecten Sollingensis, von Koenen, Palæontographica, vol. xvi, p. 228, pl. xxvi, figs. 7, 8, 1867.

,, ,, Ravn, K. Danske Vid. Selsk. Skrift (7), vol. iii, p. 251, pl. i, fig. 1, 1907.

Mus. Pract. Geol. London.

Pecten (*Chlamys*) *Hoeninghausii*, Defrance.

Pecten Hoeninghausii, Nyst, Coq. foss. Belge, p. 286, pl. xxii, fig. 2, 1843.

Pecten disparatus, S. V. Wood, Mon. Crag Moll., Suppl. 3, p. 12, pl. i, fig. 17, 1882.

Stanley Coll., Brit. Mus. (Nat. Hist.) London.

Pecten (*Chlamys*) *substriatus*, D'Orbigny.

Pecten substriatus, Hörnes, Foss. Moll. Tert. Wien, vol. ii, p. 408, pl. lxiv, fig., 1870. Harmer Coll.

Pecten (*Chlamys*) *rupeliensis* (von Koenen).

Pecten rupeliensis, von Koenen, Palæontographica, vol. xvi, p. 232, pl. xxvi, fig. 12, 1867. Mus. Pract. Geol. London, Stanley Coll.

Pecten (*Chlamys*) cf. *Ersleri*, Harder.

Pecten Erslevi, Harder, Danm. geol. Undersøg., vol. ii, p. 44, pl. iii, figs. 3, 4, 1913. Mus. Pract. Geol. London.

[A fragment in the M.P.G. seems to agree with Harder's figure.]

Pecten (*Peplum*) sp.

Pecten verrucopsis, de Gregorio, Ann. de Geol., pt. xiii, p. 26, pl. iv, figs. 89, 90, 1894.

Pecten clavatus, Ravn, K. Danske Vid. Selsk. Skrift (7), vol. iii, p. 252, pl. i, fig. 2, 1907.

Mus. Pract. Geol. London.

[Of the two figures cited above, Gregorio's comes nearest to the M.P.G. fragment.]

Pecten (*Chlamys*) *excisus*, Bronn.

Chlamys excisus, Dollfus & Cotter, Moll. Tert. du Portugal, 1909, p. 77, pl. viii, figs. 5–9.

[I found a characteristic fragment of this species in Newbourne Crag pit.]

Hinnites crispus (Brocchi).

Hinnites crispus, Sacco, Moll. Terr. terz. Piemonte, pt. xxix, p. 10, pl. ii, fig. 1, 1897. Stanley Coll.

Pinna pectinata Brocchi (D'Orbigny).

Pinna Brocchi, Hörnes, Foss. Moll. Tert. Wien, vol. ii, p. 372, pl. i, figs. 1, 2, 1870.

Pinna pectinata Brocchi, Sacco, Moll. Terr. terz. Piemonte, pt. xxv, p. 29, pl. viii, fig. 1, 1898.

Mus. York, Stanley Coll.

Mytilus corrugatus, Brongniart.

Mytilus corrugatus, Brongniart, Mém. sur les tert. du Vicentin, p. 78, pl. v, fig. 6, 1823. Stanley Coll.

Arcoperna sericea (Bronn).

Modiola sericea, Philippi, En. Moll. Sic., vol. i, p. 71, pl. v, fig. 14, 1836.
,, ,, S. V. Wood, Mon. Crag Moll., pt. ii, p. 61, pl. viii, fig. 3, 1850.

Mus. Ipswich.

Pectunculus Philippi, Deshayes.

Pectunculus pulvinatus, var., Philippi, Beit. N.W. deutsch. tert., p. 13, pl. ii, fig. 13, 1843.

Pectunculus Philippi, Ravn, K. Danske Vid. Selsk. Skrift (7), vol. iii, p. 262, pl. i, fig. 17, 1907.

Mus. Ipswich.

Pectunculus Bormidianus, Mayer.

Pectunculus Bormidianus, Mayer, Foss. Mus. Zurich, pt. iii, p. 49, 1868.

Axinea Bormidiana, Sacco, Moll. Terr. terz. Piemonte, pt. xxvi, p. 37, pl. ix, figs. 11–15, 1898.

Mus. Norwich, etc.

Pectunculus inflatus (Brocchi).

Arca inflata, Brocchi, Conch. foss. Subap., p. 494, pl. xi, fig. 7, 1814.

Axinea inflata, Sacco, Moll. Terr. terz. Piemonte, pt. xxvi, p. 32, pl. viii, figs. 1–6, 1898.

In most collections.

[*Pectunculus pilosus* and *P. glycimeris* are amongst the commonest forms in the boxstones, and probably other members of this variable group are present.]

Nucula donaciformis, Harder.

Nucula donaciformis, Harder, Danm. geol. Undersøg., vol. ii, p. 49, pl. iii, fig. 10, 1913. Stanley Coll.

Nucula placentina, Lamarck.

Nucula placentina, Philippi, En. Moll. Sic., vol. i, p. 65, pl. v, fig. 7, 1836.
,, ,, Sacco, Moll. Terr. terz. Piemonte, pt. xxvi, p. 46, pl. x, figs. 35–40, 1898.

Mus. Ipswich.

Nucula Haesendonckii, Nyst & Westendorp.

Nucula Haesendonckii, Nyst, Coq. foss. Belge, 1843, p. 236, pl. xviii, fig. 5.

[Sir E. Ray Lankester informs me that he had identified this very distinct species in the collection of the late Dr. Taylor in Ipswich. Unfortunately the specimen has been lost sight of.]

Nucula turgens, S. V. Wood.

Nucula turgens, S. V. Wood, Mon. Crag Moll., Suppl. 2, p. 44, pl. v, fig 6, 1879. Mus. Brit. Nat. Hist., Wood Coll.

Leda Deshayesiana (Du Chastel Coll.).

Nucula Deshayesiana, Nyst, Coq. foss. Belge, p. 221, pl. xv, fig. 8, 1843.
Leda Deshayesiana, Ravn, K. Danske Vid. Selsk. Skrift (7), vol. iii, p. 258, pl. i, figs. 7, 8, 1907.

Stanley Coll.

Venericardia antiquata rhomboidea (Brocchi).

Chama rhomboidea, Brocchi, Conch. foss. Subap., p. 523, pl. xii, fig. 16, 1814.
Cardita (*Glans*) *rhomboidea*, Cerulli-Irelli, Pal. ital., vol. xiii, p. 135, pl. xii, fig. 28, 1907.

Mus. York.

Astarte Henckeliusiana, Nyst.

Astarte Henckeliusiana, Nyst, Coq. foss. Belge, p. 154, pl. ix, fig. 4, 1843.
,, ,, von Koenen, Palæontographica, vol. xvi, p. 250, pl. xxix, fig. 7, 1867.

Mus. Pract. Geol. London.

Astarte Kickxii, Nyst.

Astarte Kickxii, Nyst, Coq. foss. Belge, p. 157, pl. x, fig. 3, 1843.
Astarte Kicksii, Ravn, K. Danske Vid. Selsk. Skrift (7), vol. iii. p. 268, pl. i, fig. 21, 1907.

Mus. Pract. Geol. London, Stanley Coll.

Astarte cf. *solidula*, Deshayes.

Astarte solidula tauroscalarata, Sacco, Moll. Terr. terz. Piemonte, pt. xxvii, p. 25, pl. vi, fig. 29, 1899. Mus. Pract. Geol. London.

[Length 18 mm., breadth 22 mm.; sculpture, 6 or 7 thick concentric ribs. The number of these vary according to Sacco's figures of *A. solidula*.]

Cardium cingulatum, Goldfuss.

Cardium cingulatum, Goldfuss, Petr. Germ., vol. ii, p. 222, pl. cxlv, fig. 4, 1838.
,, ,, Hörnes, Foss. Moll. Tert. Wien, vol. ii, p. 177, pl. xxv, fig. 1, 1870.

Mus. York, Ipswich.

[*C. venustum*, Lamk., *non* S. V. Wood, and *C. umbonatum*, A. Bell, *non* Sowerby.]

Cardium Woolnoughi, sp. nov.

[The species here referred to is not rare, but does not appear to have been figured or described by any Continental writer. In shape it is roundly ovate, tumid, and nearly equilateral, garnished with twenty-five to thirty narrow rounded prominent ribs continued below the lower margin with rather wider interspaces. The surface is much decorticated, leaving four or five ridges marking probably stages of growth. Mus. Ipswich.]

Cardium subdecorticatum, A. Bell.

Cardium subdecorticatum, A. Bell, Journ. Ipswich Field Club, vol. iii, p. 9, 1911.
Cardium cf. *decorticatum tenellum*, S. V. Wood, Mon. Crag Moll., pt. ii, p. 159, pl. xiv, fig. 1*d*, 1850.

In most collections.

[The above shell is decorticated as in Wood's figure, but the ribs are more open = *C. decorticatum* of Lankester and Reid.]

Isocardia cor (Linné).

Isocardia cor, S. V. Wood, Mon. Crag Moll., pt. ii, p. 193, pl. xv, fig. 9, 1850.
,, ,, Forbes & Hanley, Brit. Moll., vol. i, p. 472, vol. iv, pl. xxxiv, fig. 2, 1853.

Mus. York, Ipswich.

Isocardia lunulata, Nyst.

Isocardia lunulata, Nyst, Coq. foss. Belge, p. 198, pl. xv, fig. 2, 1843.
,, ,, Lankester, Quart. Journ. Geol. Soc., vol. xxvi, p. 502, pl. xxxiv, fig. 10, 1870.

In all collections.

Cyprina tumida, Nyst.

Cyprina tumida, Nyst, Coq. foss. Belge, p. 148, pl. x, fig. 1, 1843.
Cyprina rustica (*tumida*), S. V. Wood, Mon. Crag Moll., pt. ii, p. 197, pl. xviii, fig. 1, 1850.

Mus. York.

Cyprina scutellaria (Lamarck).

Cyprina scutellaria, Nyst, Coq. foss. Belge, p. 145, pl. vii, fig. 5; pl. viii, fig. 1, 1843. In most collections.

Cyprina islandica æqualis (J. Sowerby).

Cyprina æqualis, Goldfuss, Petr. Germ., p. 236, pl. cxlviii, fig. 5, 1838.
Cyprina islandica, S. V. Wood, Mon. Crag Moll., pt. ii, p. 196, pl. xviii, figs. 2*a*, *b*, 1850.

Cyprina islandicoides, Lamarck.

Venus islandicoides, Hörnes, Foss. Moll. Tert. Wien, vol. ii, p. 121, pl. xiii, fig. 2, 1870.
Amiantis islandicoides, Sacco, Moll. Tert. terz. Piemonte, pt. xxviii, p. 21, pl. v, figs. 1–4, 1900.

Meretrix chione, Linné.

Meretrix (*Callista*) *chione elongata*, Bucquoy, Dollfus, & Dautzenberg, Moll. du Roussillon, vol. ii, p. 328, pl. lii, fig. 10, 1893.
Meretrix (*Callista*) *chione*, Cerulli-Irelli, Pal. ital., vol. xiv, p. 43, pl. viii, figs. 9, 10, 1908.

Moore Coll.

[Major Moore has in his collection a fine mould of the interior of a shell, corresponding to the above, found at Waldringfield.]

Ventricola multilamella (Lamarck), var. *Boryi*, Deshayes.

Venus sp., Lankester, Quart. Journ. Geol. Soc., vol. xxvi, p. 502, pl. xxxiv, fig. 7, 1870.
Ventricola multilamella, Boryi, Sacco, Moll. Terr. terz. Piemonte, pt. xxviii, p. 31, pl. viii, fig. 9, 1900.

Mus. Ipswich, Stanley Coll.

[The "boxstone" mould so closely approximates to the shell figured by Sacco that it may be regarded as the same species; the more so because *V. multilamella* is somewhat variable in outline.]

Meretrix (*Callista*) *fragilis* (Münster).

Venus fragilis, Goldfuss, Petr. Germ., vol. ii, p. 247, pl. cxlviii, fig. 8, 1840.
Venus circularis, A. Bell, Journ. Ipswich Field Club, vol. iii, p. vii, 1911.

Mus. Ipswich.

Meretrix (*Callista*) *suborbicularis* (Goldfuss).

Venus suborbicularis, Goldfuss, Petr. Germ., vol. ii, p. 247, pl. cxlviii, fig. 7, 1840. Mus. Ipswich.

[The shell quoted or figured by Koninck, Nyst, Ravn, and other writers as *Venus* or *Meretrix incrassata*, Sow., does not seem to be the same as the English shell of that name.]

Tapes vetula (Basterot).

Venus vetula, Basterot, Mém. géol. sur les Env. de Bordeaux, p. 89, pl. vi, fig. 7, 1825.
Tapes vetulus, Dollfus & Dautzenberg, Mém. Soc. géol. France, vol. xiv, p. 176, pl. ii, figs. 1–6, 1906.

Mus. Pract. Geol. London.

Donax minutus, Bronn.

Donax minutus, Sacco, Moll. Terr. terz. Piemonte, pt. xxix, p. 4, pl. i, figs. 8, 9, 1901. Mus. Pract. Geol. London, Ipswich.

Solenocurtus Basteroti, Desmoulins.

Solenocurtus Basteroti, Sacco, Moll. Terr. terz. Piemonte, pt. xxix, p. 15, pl. iv, fig. 1, 1901.
,, ,, Dollfus, Cotter, & Gomes, Moll. tert. Portugal, p. 27, pl. i, figs. 7–10, 1903.

Mus. Pract. Geol. London.

Solen (*Ensis*) cf. *Rollei* (Hörnes).

Ensis Rollei, Hörnes, Foss. Moll. Tert. Wien, vol. ii, p. 15, pl. i, fig. 14, 1870.
,, ,, Dollfus & Dautzenberg, Mém. Soc. géol. France, vol. x, p. 65, pl. ix, figs. 35–8, 1902.

Mus. Ipswich.

Mactra miocænica, Dollfus & Dautzenberg.

Mactra miocænica, Dollfus & Dautzenberg, Mém. Soc. géol. France, vol. xi, p. 109, pl. vi, figs. 10, 11, 1904. Mus. Pract. Geol. London, Ipswich.

[*M. podolica*, Hörnes, Foss. Moll. Tert. Wien, vol. ii, p. 62, pl. vii, fig. 5, may be a variant of this species.]

Mactra triangula, Renier.

Mactra triangulata, S. V. Wood, Mon. Crag Moll., 1850, pt. ii, p. 325, pl. xxi, fig. 21. Stanley Coll.
Mactra trinacria, Speyer, Palæontographica, vol. xvi, p. 34, pl. iii, fig. 4, 1861. Mus. Pract. Geol. London, York.

[The principal difference between *M. triangulata* and *M. trinacria* seems to be that the latter forms a more equilateral triangle than the other. Both are probably related to the recent *M. elliptica*.]

Lutraria sanna, Basterot.

Lutraria sanna, Basterot, Mém. géol. sur les Env. de Bordeaux, p. 94, pl. vii, fig. 13, 1825.
,, ,, Sacco, Moll. Terr. terz. Piemonte, pt. xxix, p. 31, pl. viii, fig. 5, 1901.

Mus. Pract. Geol. London, Ipswich.

Lutraria ovalis, sp. nov.

Lutraria sanna, Hörnes, Foss. Moll. Tert. Wien, vol. ii, p. 56, pl. v, fig. 5, 1870.
,, ,, Dollfus, Cotter, & Gomes, Moll. tert. du Portugal, p. 30, pl. iv, fig. 4, 1903.

[Allied to *L. oblonga*, Chemnitz.]

Lutraria elliptica Jeffreysii, De Gregorio.

Lutraria elliptica Jeffreysi, De Gregorio, Boll. Soc. malac. ital., vol. x, p. 143.
Lutraria lutraria Jeffreysi, Cerulli-Irelli, Pal. ital., vol. xv, p. 143, pl. xv, fig. 9, 1909.

Mus. Pract. Geol. London, Norwich, Ipswich.

Corbulomya complanata, var. B, Nyst.

Corbulomya complanata, Nyst, Coq. foss. Belge, p. 59, pl. ii, fig. ii, 1843. Stanley Coll.

Panopæa Menardi, Deshayes.

Panopæa Menardi, Hörnes, Foss. Moll. tert. Wien, vol. ii, p. 29, pl. ii, figs. 1–3, 1870.
Glycimeris Menardi, Sacco, Moll. Terr. terz. Piemonte, pt. xxix, p. 43, pl. xii, fig. 4, 1901.

In most collections.

Panopæa declivis, Michelotti.

Lutraria declivis, Michelotti, Etud. Mioc. Inf. d'Ital., p. 57, pl. vi, fig. 1, 1861.
Glycimeris intermedia declivis, Sacco, Moll. Terr. terz. Piemonte, pt. xxix, p. 45, pl. x, fig. 6, 1901.

Mus. Pract. Geol. London.

Panopæa Gastaldi (Michelotti).

Panopæa Gastaldi, Michelotti, Etud. Mioc. Inf. d'Ital., p. 54, pl. v, fig. 10, 1861.
Glycimeris intermedia Gastaldi, Sacco, Moll. Terr. terz. Piemonte, pt. xxix, p. 45, pl. x, fig. 4, 1901. Mus. Ipswich.

Panopæa (?) *acutangula* (Michelotti).

Lutraria acutangula, Michelotti, Etud. Mioc. Inf. d'Ital., p. 57, pl. vi, fig. 2, 1861.
Glycimeris intermedia acutangula, Sacco, Moll. Terr. terz. Piemonte, pt. xxix, p. 46, pl. xii, fig. 10, 1901.

Mus. Ipswich.

Cyrtodaria vagina (S. V. Wood).

Glycimeris angusta, S. V. Wood, Mon. Crag Moll., pt. ii, p. 291, pl. xxix, fig. 2, 1850. Mus. Pract. Geol. London.

[I do not think this to be the same shell as the *Glyc. angusta* of Nyst's memoir, pl. ii, fig. 1. The latter has a more pointed extremity. This I have had from the Red Crag. Mr. Stanley has a small shell in his sandstone collection from Bawdsey which may be the same.]

Lucina (*Dentilucina*) *Barrandei*, Mayer.

Lucina Barrandei, Mayer, Journ. de Conch., vol. xix, p. 340, pl. x, fig. 1, 1871.
Dentilucina Barrandei, var., Sacco, Moll. Terr. terz. Piemonte, pt. xxix, p. 83, pl. xix, figs. 7–9, 1901.
Lucina Canhami, A. Bell, Journ. Ipswich Field Club, vol. iii, p. 9, 1911.

Mus. Ipswich.

Syndosmya sp.

[Two or three species of this group are present in the "boxstones", possibly the *Erycina longicallis* and *E. similis*, figured in Philippi, En. Moll. Sic., vol. ii, pl. xiii, figs. 7, 8, but they are not sufficiently definite for accurate determination. Stanley Coll.]

Syndosmya prismatica (Montagu).

Ligula donaciformis, Nyst, Coq. terr. Belge, p. 92, pl. iv, fig. 9, 1843.
Abra prismatica, S. V. Wood, Mon. Crag Moll., pt. ii, p. 239, pl. xxii, fig. 13, 1850.

Mus. Pract. Geol. London, York.

Thracia ventricosa, Philippi.

Thracia ventricosa, Philippi, En. Moll. Sic., vol. ii, p. 17, figured in vol. i, pl. i, fig. 10 (as *T. pubescens*), 1844.
Thracia ventricosa, S. V. Wood, Mon. Crag Moll., Suppl. 2, p. 48, pl. v, fig. 3, 1879.

Mus. Ipswich.

Teredo borings in wood are not uncommon, but the shells have entirely disappeared.

[Certain shells of pre-Crag origin are found in the Oakleyan and Newbournian zones of the Red Crag, and as some of these also occur embedded in the boxstones they are presumably of the same age.

Most of these are figured by Mr. S. V. Wood in the Supplements to the Crag Mollusca, and by Mr. F. W. Harmer in the Monograph on the Pliocene Mollusca now in course of publication.

A few like the *Rimellæ*, *Serpulæ*, *Turritellæ*, and *Venericardia* occur in profusion, but as a rule the majority are single specimens, as in the following list:—

Borsonia suffolciensis.
Pleurotoma denticulata.
,, *interrupta.*
,, *nodifer.*
,, *plebeia.*
,, *Selysii.*
Cancellaria evulsa.
Ancillaria glandiformis.
Volutilithes luctatrix.
,, *nodosa.*
,, *suturalis.*
Mitra fusiformis (?).
Fusus abrasus.
,, *crispus.*
Purpura derivata.
Stenomphalus Weichmanni.
Triton connectens.
Ranella (?) *anglica.*
Semicassis saburon.
Rimella, two or three species.
Turritella, two or three species.
Solarium, two or three species.
Ostrea, two or more species.
Pecten Hœninghausii.
,, *Sollingensis.*
Venericardia, several varieties.
Lucina crassidens.

I have not seen any specimens of the typical *Voluta Lamberti* of the English or Belgian Crags, or of *Pyrula* (*Ficula*) *reticulata*, or *Cassidaria bicatenata* in the "boxstones". The latter, however, is said to occur sparingly in the "Sables noirs d'Anvers".

Voluta Lamberti, *Atractodon elegans*, and *Cassidaria bicatenata* are occasionally washed ashore on the coast, from Aldborough to Walton-on-the-Naze,

derived from some deposit probably of Diestian or Anversian age. Mr. Harmer has in his collection a worn shell of the *V. Lamberti* group, showing distinctly broad and swollen ribs on the upper whorls obtained from the Felixstowe shore.

Very few invertebrate remains other than the Mollusca have been obtained in the East Anglian area. I have only noticed, or found recorded :—

Crustacea.

Cœloma sp. (? *rupeliense*, Strainer), and segments of a narrow lobster-like species.
Balanus inclusus (*fide* Lankester), *B. unguiformis.*

Radiata.

Cyphosoma tertiarium, Cotteau.
Diadema megastoma, A. Bell.
Solaster Reedi, n.sp.

[This unique example belongs to the Reed Collection in the York Museum. It exhibits the dorsal surface of a thick fleshy starfish, covered with bunches of short fasciculate spines scattered over the surface, as they are in the recent *S. furcifer*.

Mr. W. K. Spencer, F.G.S., has kindly furnished me with the following notes of dimensions : "Major radius 33 mm. (approx.), minor radius 13 mm., width of arm at base 14 mm., no. of arms six."]

Cœlenterata.

Flabellum cuneata, Goldfuss, and another species.
Solenastrea Prestwichii, Duncan.
Trochocyathus anglicus, Duncan.

Woods, fruits, and nuts are common in the Belgian Rupelien deposits, and our sub-Crags are rich in these. Mr. W. Carruthers told me many years ago that he had determined three Angiospermous Dicotyledons, one conifer, and two palms. Certain plants or fruits retain their forms when phosphatized both in exterior shape and internal structure, but whether these have any relations to either of the woods present is not yet known. Mus. Ipswich, Saffron Walden.

Amber has been obtained from the Cromer Forest Bed, and Mr. C. Reid has referred to a variety of spiders, insects, etc., in amber washed up on the East Anglian coast, Trans. Norfolk and Norwich Nat. Hist. Soc., vols. iii–v. Mr. A. H. Foord, F.G.S., in vol. v, p. 92, figures many of these, including bees, beetles, cockroaches, and spiders, submitted to, and partly named by, Mr. C. O. Waterhouse and the Rev. O. P. Cambridge. Whether of the same age as the above woods has yet to be determined.

NOTICES OF MEMOIRS.

I.—On Mammalian Bones from Excavations in the London District. By Arthur Smith Woodward, LL.D., F.R.S.[1]

In an area so long populated as the London district the surface deposits are naturally very varied, and those of the historic period contain remains not only of the indigenous fauna but also of man's accidental importations. Even so late as the twelfth century William Fitzstephen wrote that the woods close to the city were well stocked with game—"stags, fallow-deer, boars, and wild bulls." Their bones and teeth are often found, besides the remains of other animals, perhaps partly of somewhat earlier date, among which the beaver is especially interesting. Bones of the beaver are indeed so

[1] Abstract of a lecture delivered to the South-Eastern Union of Scientific Societies at Burlington House, London, on June 7, 1917.

abundant in the marsh deposits of the Lea Valley, Essex, that this animal probably had much to do with the extension of the swamps in that region. A good skeleton of a beaver was found in 1911 when excavating at the Royal Victoria and Albert Docks.

Until comparatively recent times much of the land now covered with houses was occupied by market gardens, which it was customary to ornament with trophies brought home by sailors. Among these may be specially mentioned the ribs and jaws of whales, which were erected as arches or made into seats, and disappeared by burial as soon as building operations began. Remains of the oxen, sheep, and pigs used for food were also often buried, and heaps of them have been found in some places, such as Moorfields. They should be collected with care when circumstances allow of their being dated, because it is interesting to determine the successive breeds which they represent. Exceptional accumulations of bones are sometimes puzzling and less easily explained than one which I saw in the mud filling a former pond at Earl's Court House when it was dismantled in 1884. Here lived the eminent surgeon John Hunter, who thus disposed of the remains of many of the carcases he dissected.

Below the very irregular surface deposits of London there are the old gravels, with associated sand, brick-earth, and peat, of Pleistocene age, occurring at different levels above the Thames, which laid them down before it had cut out the valley to its present depth. Excavations in these river terraces yield mammalian bones almost everywhere.

Sometimes a cold or Arctic fauna is met with. A fine large antler of reindeer and part of the frontlet of a bison were dug up in Buckingham Palace Road in 1891, and similar remains were again found associated at Twickenham in 1894. With the latter Dr. J. R. Leeson discovered a characteristic frontlet of the saiga antelope, which lives now only on the steppes to the east of the Volga. A still more Arctic animal, the musk-ox, is represented in the British Museum by fragments from Plumstead Marshes, Crayford, and Maidenhead. Remains of the mammoth (*Elephas primigenius*) occur abundantly, and some of the best specimens have been found at the bottom of the Thames deposits, directly on the London Clay. Several parts of the skeleton of a young mammoth were discovered thus in an excavation at Endsleigh Street, Bloomsbury, in 1892. More fragmentary remains of the same animal were dug up in 1903 and 1909 in a peaty bed on the London Clay beneath the *Daily Chronicle* office, Fleet Street, associated with very fine skulls of old and young individuals of the woolly rhinoceros (*Rhinoceros antiquitatis*), which were given to the British Museum by Mr. Frank Lloyd. More recently part of the humerus of a lion has been found in the same deposit.

Evidence of a warmer Pleistocene fauna occurs in several places, and the collection of bones and teeth obtained in 1879 from the foundations of Drummond's Bank, Charing Cross, may be mentioned in illustration. I am indebted to Mr. Charles Drummond and the Manager of the Bank for the opportunity of examining this collection, which is still preserved there. The lion is represented by three

vertebræ, part of a sacrum, the middle piece of a humerus, and a calcaneum. There is a characteristic molar tooth of the southern elephant, *Elephas antiquus*, while three fragments of tusk and some portions of limb-bones may well belong to the same species. Two bases of shed antlers evidently represent the large extinct fallow deer, *Cervus browni*, and other bases of antlers are characteristic of *Cervus elaphus*. Numerous bovine limb-bones are very variable in size and proportions, and may belong either to *Bos primigenius* or to a *Bison*. Fragments of limb-bones of a small *Rhinoceros* are not specifically determinable. The absence of *Hippopotamus* is curious, but remains of this animal have been found not far away in Cockspur Street and beneath the Admiralty Offices.

In the London district, as in other parts of Southern England, there is thus some evidence that the typically warm and typically cold members of the Pleistocene mammalian fauna were not altogether contemporaneous.

II.—A Geological Theory of the Origin of Man.

Probable Relations of Climatic Change to the Origin of the Tertiary Ape-Man. By Professor Joseph Barrell. *The Scientific Monthly* (New York), vol. iv, pp. 16–26, 1917.

LAST year (Bull. Geol. Soc. America, vol. xxvii, pp. 387–436) Professor Barrell pointed out that recurrent periods of semi-arid conditions might have had much influence on the evolution of vertebrate animals. As a dry season advanced, rivers would be reduced in flow, stagnant pools would result, and any fishes which endured these changed conditions would have to become much modified. The primitive sharks, for instance, found in the earliest Palæozoic freshwaters, having no air-bladder, would be driven to the seas. The freshwater fishes which remained were ganoids and dipnoans, with an air-bladder efficient for the direct use of air. From the crossopterygian ganoids, under the stimulus of the semi-aridity of the Devonian period, there arose the amphibians capable of existing as land animals; and so on.

The question now arises as to whether a similar climatic change in the Tertiary period, acting on species of large-brained and progressive anthropoid apes, isolated from forest regions, might not cause them to advance and become adapted for life on plains or die out. Professor Barrell thinks it would be so, and mentions that at the close of the Miocene period climatic conditions were such that this latest evolution may actually have occurred. There were at that time numerous apes in the warm forests south of the Himalayan region. As the mountains rose and the temperature was lowered some of the apes may have been trapped to the north of this area. As comparatively dry plains took the place of forests, and as the apes could no longer migrate southwards, those that survived must have become adapted for living on the ground and acquired carnivorous instead of frugivorous habits. The Miocene or early Pliocene ape-man may therefore be more hopefully sought in deposits of the open and temperate regions of Central Asia than in the alluvial deposits of the more southern tropical forests.

III.—Glastonbury Lake-Village.

THE second volume of Messrs. Bulleid & Gray's report on the Glastonbury Lake-Village is just published. It is most valuable, and reflects the highest credit on the authors. This volume contains much matter of geological interest in addition to the archæology. There are reports on the plants by Clement Reid, on the bird remains by C. W. Andrews, on the wild and domestic mammalia by W. B. Dawkins & J. W. Jackson, and on the humans by W. B. Dawkins. The illustrations are profuse and excellent, and the report as a whole is as complete an account of such a site as has yet been made available.

Among the vertebrates the bird *Pelecanus crispus* is the most interesting, for although remains have been previously found in the Fens, Dr. Andrews has examined portions of five individuals and many fragments from Glastonbury, clearly indicating that the birds bred in the neighbourhood, and possibly pointing to a source of food for the inhabitants. The report closes with an exhaustive index, most wisely provided, which greatly enhances its value.

REVIEWS.

I.—Microscopical Determination of the Opaque Minerals. By Joseph Murdoch. pp. viii + 165, with 9 figures in the text and 1 coloured plate. New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1916. Price 9*s.* 6*d.* net.

WHY the microscope, while holding so predominant a position in the determination of rocks by means of the characters revealed in a thin slice and in the study of transparent substances generally, has hitherto been so little used in the study of metals and alloys and in the identification of opaque substances, is perhaps not difficult to understand. It is not at first sight by any means obvious that this instrument is at all suitable for the purpose, and so vast was the vista opened out by the application of the microscopical method to petrological work that the equally important field of research lying fallow in the case of opaque substances for a long time almost entirely escaped notice. It was, in fact, not till the discovery of different kinds of hardened steels and the consequent necessity for determining and explaining their various characteristics that metallurgists began to pay general attention to the microscopic study of polished sections. Yet more than half a century has elapsed since the gifted Sorby, to whom we are likewise indebted for drawing general attention to the advantage of the microscopic study of thin slices of rocks, had made use of practically all the devices in vogue among metallurgists of to-day; while it is only within the past four or five years that anything like a systematic study of the opaque minerals has been attempted. Mr. Murdoch's book marks the beginning of a new epoch. Previous writers and workers had confined their attention to some particular mineral group or some isolated problem. He is the first to make a systematic study of the opaque minerals, and above all to think out and develop

a scheme for identifying them by the characters revealed under the microscope.

After a full historical account of the work of previous writers—not a great number—the author carefully describes the comparatively simple apparatus required for the preparation of suitable polished sections, and gives a list of the reagents which are used in microchemical work. The opaque minerals are divided into three main groups: coloured, white, grey. Difference in hardness as compared with a steel needle and the behaviour when treated with certain reagents are made use of for further subdivisions until the mineral species in question is finally run down. The white group is a large one, and for subdivision reliance is placed upon the tint as compared with the standard white of galena. Mr. Murdoch asserts that after a little practice the eye can unerringly appreciate such slight differences as greyish white, pinkish white, bluish white, and creamy white. A correct determination at this stage is important, since otherwise much time may be lost in following a false trail. The arrangement of the copious tables is the most remarkable feature of the book. By an ingenious use of cutting or "tabbing" the upper and side edges of the leaves reference to the tables is rendered easy, and to prevent mistakes the order of the tests is printed on the upper left-hand corner of the left-hand page.

This is, in short, a book that should be in the hands of every metallurgist or mineralogist.

II.—The Economic Geology of the Central Coalfield of Scotland. Description of Area V (Glasgow East, Chryston, Glenboig, and Airdrie). Mem. Geol. Survey Scotland. pp. viii + 146, with 13 plates and 5 figures. 1916. Price 4*s*. 6*d*.

THIS memoir is the first to be published of a series intended to provide a description of the economic geology of the central coalfield of Scotland. The area dealt with includes a large part of the city of Glasgow, and extends eastwards beyond Airdrie, with a tongue projecting beyond Longriggend into Linlithgowshire. The strata included all belong to the Carboniferous system, overlain in places by a considerable thickness of superficial deposits, both glacial and post-glacial, and there are a good many intrusive sills and dykes of dolerite, often containing analcime. As is well known, coal is largely developed in Scotland in the Lower Carboniferous, while the upper part of the Upper division is barren.

The memoir contains a detailed description of the coal-bearing strata of the district, again subdivided into four areas. This information is very largely derived from the records of mine-shafts and borings. From the manner in which it is presented it is evident that the memoir is intended mainly for the "practical man", since these portions are written in a language unintelligible to the ordinary scientific geologist. Among the descriptive petrological terms we find for example: stone, rib, metal, fakes, blaes, selit, and daugh, without any explanation, while from the context it can be gathered that in the local patois "float" means a sill.

In spite of this drawback it is evident that the memoir contains a vast store of information which in this collected form must be of the utmost value to those concerned with the purely economic side of the subject. The dominant geological structures and the disposition of the principal faults and folds are clearly brought out, and there is also a brief but interesting chapter on the value of fossils, illustrated by two good plates, one of marine and freshwater shells, admirably drawn by Dr. Peach, and the other of some photographs of characteristic Coal-measure plants, contributed by Dr. Kidston. There are also some useful tables of analyses and physical data connected with fire-clay, which is largely developed in the district.

R. H. Rastall.

III.—Western Australia. Annual Progress Report of the Geological Survey for the year 1915, with an Index Map. Folio; pp. 44. Perth, 1916.

THIS work contains the following reports:—

1. The Building Stones of Western Australia, by H. P. Woodward, which includes a scheduled list of the Acid Igneous Rocks.

2. The Limestone Deposits near Denmark, by H. P. Woodward, with analyses by E. S. Simpson.

3. The Foraminiferal Sand Deposits of Dongara, by H. P. Woodward, with tabulated analyses and tests by E. S. Simpson.

4. The Commercial Application of the Dongara Foraminiferal Sands, by E. S. Simpson.

5. The Limestone Deposits of the Geraldton Districts, by H. P. Woodward, with chemical reports by E. S. Simpson.

6. Supplementary Report on the Limestone Deposits at Yonga (Martyup), by H. P. Woodward.

7. Yilgarn Goldfield, by T. Blatchford.

8. Kookynie and Tampa, by J. T. Jutson.

9. Albany, by J. T. Jutson and E. S. Simpson.

10. The Reported Occurrence of Oil near Wonnerup, South-West Division, by E. de C. Clarke, with an appendix by E. S. Simpson "On Samples of supposed Petroleum-bearing Earths and Water from Wonnerup".

11. Meekatharra, by E. de C. Clarke, with notices of the Acid, Basic, and Metamorphic Rocks of this district.

12. The North End (Kalgoorlie), by F. R. Feldtmann. Contains a detailed classification of the rocks of this region based upon the petrological examination of many specimens.

13. The Magnesite Deposit at Bulong, North-East Coolgardie Goldfield, by F. R. Feldtmann.

14. Geological Report on the Canning River Dam Site, No. 2, by F. R. Feldtmann.

15. The Occurrence of Gold at North Dandalup, by C. S. Houman.

16. Yerilla District, by C. S. Houman.

IV.—Western Australia. Geological Survey, Bulletin No. 63. The Geology and Mineral Resources of the Yilgarn Goldfield. Part II: The Gold Belt south of Southern Cross. By T. Blatchford, B.A., Assistant Geologist, with Petrological Notes by R. A. Farquharson, M.A. (Oxon.), etc., and Mineralogical Contributions by E. S. Simpson, B.E., etc., and A. J. Robertson, M.Sc. Issued under the authority of the Hon. P. Collier, M.L.A., Minister of Mines. pp. 189, with nineteen plates (maps and plans) and thirty-one figures (views showing geological phenomena, etc. Perth, 1915.

THE reports of this Bulletin are regarded as of great importance, since no detailed geological work has been previously published on the southern portion of the Yilgarn Goldfield. The Government Geologist, Mr. A. Gibb Maitland, regards this work as "a notable contribution to the geology of the portion of the State's goldfields of which it treats".

V.—Western Australia. Geological Survey, Bulletin No. 66. The Geology of the Country to the South of Kalgoorlie (Coolgardie and East Coolgardie Goldfields), including the Mining Centres of Golden Ridge and Feysville. By C. Sidney Houman, B.M.E. (Melb.), Field Geologist. Issued under the authority of the Hon. P. Collier, M.L.A., Minister for Mines. pp. 75, with nine plates (maps, sections, etc.) and seventeen figures (plans, sections, etc.). Perth, 1916.

IN a prefatory note the Government Geologist, Mr. A. Gibb Maitland, mentions that this report contains the results of an examination of about 700 square miles of country in portions of the Coolgardie and East Coolgardie Goldfields, lying to the south of Kalgoorlie and coterminous with that described in Bulletin 56.

VI.—A Bibliography of Fishes.

A Bibliography of Fishes, by Bashford Dean and C. R. Eastman, Amer. Mus. Nat. Hist., 1916, has just reached us, that is to say vol. i, containing author titles A–K, which alone occupy 718 pages in double column.

This work deals with fishes broadly (including Cyclostomes and *Amphioxus*), their habits, structure, development, physiology, pathology, distribution, and kinds. It does *not* include detailed references to species, genera, or even, in many cases, families. Nor does it treat of the vast economic interests of the group. These matters would entail years of labour and many volumes of additional print.

Vol. ii will conclude the author titles, and vol. iii will list up anonymous works, pre-Linnæan works, bibliographies, voyages and expeditions, special periodicals, and a complete index of subjects.

The collection of the material commenced in 1890, by 1900 had reached 20,000 cards, and now numbers 40,000 titles. Dean, Eastman, Hussakoff, v. Kupffer, A. Boehm, L. Neumayer, Brown, Goode, and F. J. Cole, all contributed to its preparation, aided by

a staff of women clerks, and even thus thirty years have almost slipped away. Our thanks go out to all these workers.

It is only by these combined labours that work will be possible in the future. Indeed, it might be well if some encouragement were offered to those who devote themselves to compilations which quarter the work of the specialist, but are often the object of his indifference, and which (*crede experto*) he is sometimes too lazy even to use.

VII.—Tibetan Palæontology.

Le Crétacé et l'Eocène du Tibet Central. By Professor Henri Douvillé. Palæontologia Indica, 1916, new series, vol. v, Memoir No. 3, pp. 1–46, pls. i–xvi. Appendix by M. L. Morellet: Note sur les Algues Siphonées Verticillées, pp. 47–9, text-figures. Price 4 rupees, or 5*s.* 4*d.*

THIS memoir is descriptive of a collection of fossils obtained by the Tibetan Frontier Mission of 1903–4, under Colonel Sir F. E. Younghusband, of which Mr. H. H. Hayden (the present Director of the Geological Survey of India) was the Geologist in charge. Mr. Hayden has already published two important memoirs on the geological results of the expedition (Records Geol. Surv. India, vol. xxxii, pp. 160–74, pl. vii = geological map, 1905, and Mem. Geol. Surv. India, vol. xxxvi, pt. ii, pp. 122–201, with plates, sections, views, and map, 1907), in which a good general account is given of the specimens collected, together with the different horizons which they indicated.

The stratigraphy of the region as therein explained is briefly as follows: Supposed Palæozoic rocks, without fossils, in the Khonbu Valley; Trias (?), east of Dothak, with indeterminable Pelecypoda; Jurassic at Tsang and Ü, containing *Trigonia*, *Harpoceras*, etc.; Spiti Shales with characteristic Ammonites at Kampa Dzong; while Cretaceous and Tertiary formations, grouped as the "Kampa Series", were developed at Kampa Dzong and Tuna, from which the chief fossils were obtained. The Kampa Series being highly fossiliferous enabled Mr. Hayden to divide its Cretaceous portion into the Cenomanian, Turonian, Senonian, and Maestrichtian stages, the Tertiary being regarded as Eocene and the equivalent of the Lower Ranikot deposits of Western Sind, chiefly on account of the presence of what was determined as *Velates schmideliana*.

As a resumé of Hayden's researches further valuable remarks on the Cretaceous and Eocene stratigraphy of this region were made by Mr. Vredenburg in his paper on the Cretaceous Orbitoides of India (Records Geol. Surv. India, vol. xxxvi, pp. 186–90, 1908). From an examination of the fossils he was of opinion that the Tibetan Cretaceous sequence resembled that of Baluchistan, Persia, and Southern India, and that the Eocene corresponded with the Lutetian of Europe and the Laki group of India.

The present monograph deals exclusively with the palæontology of the "Kampa Series" (named after Kampa Dzong, nearly 200 miles south-west of Lhasa), several of Hayden's determinations being preserved, while others have been revised and added to in consequence

of a more complete study of the fauna. A later stage is recognized among the Cretaceous rocks, viz. the Danian, in which is included *Velates tibeticus*, n.sp., a Gasteropod presenting considerable differences of form from the well-known *V. schmideliana* of older Eocene times, with which it had been confused by Hayden. A special chapter is devoted to the Orbitoides of the collection, which were recognized as belonging to the Campanian, Maestrichtian, and Danian, full acknowledgment being given to Mr. Vredenburg's important memoir on *The Cretaceous Orbitoides of India* previously referred to. The Eocene beds, having yielded *Alveolina*, *Orbitolites*, etc., are regarded as *Eocène inférieur*, but older than the Ranikot Beds of India. The author admits a continuity of deposits from Cretaceous times, a fact suggested by Hayden, who was unable to trace the existence of any unconformity between the Cretaceous and Tertiary—such a conclusion, we think, being also supported by reason of the absence of Nummulites in those rocks. For a better appreciation of the entire fauna the following list of its species and those of the Algæ, now described and mostly figured, is here appended:—

Cenomanian: *Acanthoceras newboldi*, Kossmat; *Mantelliceras laticlavium* (Sharpe); *M. discoidale* (Kossmat); *Turrilites costatus*, Lamarck; *T. wiestii*, Sharpe; *T. desnoyersi*, Orbigny. **Turonian** (?): *Inoceramus* sp.; ? *Plicatula radiola*, Lamarck; *Pycnodonta vesiculosa* (J. Sowerby). **Emscherian**: *Pycnodonta*. **Campanian**: *Actæonella crassa* (Dujardin); *Bournonia haydeni*, n.sp.; *B. tibetica*, n.sp.; *Endocostea haydeni*, n.sp.; *Lima* sp.; *Pycnodonta vesicularis* (Lamarck). **Maestrichtian**: *Nerinea ganesha*, Noetling; *Plagioptychus tibeticus* n.sp.; *Plicatula hirsuta*, Coquand; *Kingena heberti* (Orbigny); *Cymopolia tibetica*, n.sp. **Danian**: *Nautilus pseudobouchardi*, Spengler; *N.* cf. *rota*, Stoliczka; *Gisortia depressa* (J. de C. Sowerby); *Ocula* cf. *ellipsoides*, Archiac & Haime; *O.* sp.; *Terebellum distortum*, Archiac & Haime; *Gosavia salsensis* (Archiac & Haime); *Lyria* sp.; *Chenopus tibeticus*; *C.* (*Hippochrene*) *columbarius* (Lamarck ?), Archiac and Haime; *Drepanochilus fusoides* (Archiac); *Campanile* cf. *breve*, H. Douvillé; *C. brevius*, n.sp.; *Natica* cf. *flemingi*, Archiac & Haime; *Velates tibeticus*, n.sp.; *Venericardia*; *Corbis* cf. *lamellosa*, Lamarck; *Lima squamifera*, Goldfuss; *Chama* cf. *distans*, Deshayes; *Spondylus rouaulti*, Archiac; *Delheidia haydeni*, n.sp.; *Orbitoides vredenburgi*, n.sp.; *O. media*, Archiac; *O. tenuistriata*, Vredenburg; *Lepidorbitoides socialis* (Leymerie); *L. tibetica*, n.sp.; *L. polygonalis*, n.sp.; *Omphalocyclus macropora* (Lamarck); *Operculina canalis*, Archiac; *O. hardiei* (Archiac & Haime); *Siderolites miscella* (Archiac & Haime). **Eocene**: *Coniscala tibetica*, n.sp.; *Vulsellopsis legumen* (Archiac & Haime); *Liostrea flemingi* (Archiac & Haime); *Alveolina oblonga*, Orbigny; *Orbitolites complanatus*.

We must congratulate Professor Douvillé on the production of so excellent a work, more especially as we are given to understand that it was difficult of achievement on account of the bad preservation of the fossils. All palæontologists interested in the geology of this remote and little-known region of Asia will welcome so important and valuable a contribution to the literature of that subject.

R. B. N.

REPORTS AND PROCEEDINGS.

Mineralogical Society.

June 19.—W. Barlow, F.R.S., President, in the Chair.

Dr. G. F. Herbert Smith: On the Problem of Sartorite. The examination of crystals kindly supplied for the purpose by Dr. C. O. Trechmann and Mr. R. H. Solly showed that the faces fall into zones which are only partially congruent. Just as in the case of calaverite earlier investigated by the author, there appear to be simultaneously in certain of the crystals five distinct lattices. The vertical spacing and the relative positions of the vertical planes remain unchanged, but in passing from the central lattice to the two lying on either side there is a distinct shear which varies in direction, though apparently not in amount, from crystal to crystal.

Dr. A. Scott: Note on a Curious Case of Devitrification. The glass of an old bottle found in river sand about four feet below the surface in Leven Shipyard, Dumbarton, has become almost completely crystallized. The crystals, which have a composition corresponding nearly to $2CaO \cdot Na_2O \cdot 5SiO_2$, are accompanied by some dark-coloured microlites. A piece of a glass which by accident had been allowed to cool slowly showed the same crystals and microlites, and in addition a few small needles with high refraction and large birefringence.

Dr. G. T. Prior: The Meteorites of Simondium, Eagle Station, and Amana. The results of analyses showed that the Amana stone belonged to the cronstadt, with some approach to the baroti type; that Eagle Station is an exception to other pallasites in containing iron richer in nickel and olivine correspondingly richer in ferrous oxide; and that Simondium was closer to the grahamites than to the howardites, since like other grahamites it contained nickeliferous iron and olivine in chemical composition similar to those of the pallasites, but with pyroxene and anorthic felspar similar to those of the howardites and eucrites.

CORRESPONDENCE.

FROM THE FRONT.

Dear Dr. Woodward,—I have by no means forgotten your kind letters, but I have not been in a position to write to you of late. The business in the Artillery line has been far too brisk to allow me quiet to get any correspondence done. Fortunately for me, the other night I did not retire to rest at my usual time, for my "dug-out" fell in and buried my "kit" under 8 foot of earth, so I cannot grumble at my luck, even though I have been out here now nine months without any leave.

Strangely enough, the fall of my "dug-out" brought out a rather interesting little geological section: a pocket of chalk about a foot in greatest diameter, with streaks running out of it for about 2 feet in one direction only, was exposed in the sandy cliff, though the solid chalk below had still another 15 feet of sand separating it from this pocket. The other day also I came across the finest illustration of